ENGINEERING NEWS

A JOURNAL OF CIVIL, MECHANICAL, MINING AND ELECTRICAL ENGINEERING

Vol. LIV. No. 5. 220 Broadway, New York, August 3, 1905.

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THE GREAT BLAST AT HENDERSON'S POINT, PORTSMOUTH NAVY YARD.

Not since the blowing up of Flood Rock, a nine-acre obstruction in New York harbor, has any submarine blast been fired that compares in magnitude with the explosion of the 38 tons of dynamite at Henderson's Point, July 22.

But aside from the mere size of the blast, contractors and engineers will be particularly interested in it because of the methods employed in drilling and charging the holes. It seldom happens that a hole longer than 30 ft. is drilled with an air drill, so that the drilling of a lift hole 79 ft. long is in itself worthy of special notice. The photograph, Fig. 1, serves to impress one with the enormous length of one of the drill steels, this particular steel being 68 ft. long, made of 1¾-in. stock.

Henderson's Point was a ledge of trap rock 400 ft. wide at the base and projecting 300 ft. into Portsmouth Harbor in such a manner as to make it extremely difficult for large war vessels to reach the new dry dock. The area of rock to be excavated to a depth of 35 ft. below low water was about three acres, and the contractors decided to build a cofferdam of horse-shoe shape and excavate all the rock possible within this cofferdam by ordinary methods. By doing this a rim of rock was left under the cofferdam and extending out beyond it into the harbor. This rim of rock contained approximately 35,000 cu. yds., which was broken up by the single huge blast about to be described.

THE 38-TON DYNAMITE BLAST, HENDERSON'S POINT, PORTSMOUTH HARBOR.
(Photograph Copyrighted, 1905, by Geo. Brayton, Boston.)

At first some attempts were made to excavate the rim by drilling vertical holes from scows, and blasting in the way commonly adopted for submarine work; but the swiftness of the tide and the slowness of the work led the contractors to adopt a novel method. They tried the experiment of drilling "lift holes," using the large Ingersoll-Sergeant, H9, submarine drills, mounted, as shown in Fig. 2, on timbers laid in the bottom of the pit excavated inside the cofferdam. In this way 203 lift holes, having a dip of 1 in 10 from the horizontal, were drilled 50 to 79 ft. deep, and 5 ft. apart, all around the inside of the pit. The holes started 1 ft. below the bottom of the grade to which dredging must be carried, so as to make sure of leaving no "hog backs" after blasting.

The diameter of the holes at the collar was 6 ins., and the deepest holes were 2 ins. in diameter at the bottom. A cross-bit was used for starting a hole, but plain chisel bits were found very effective for the greater depths, although they were not always used. The rock was exceedingly "blocky" and seamy, many hard quartz veins occurring at frequent intervals in some holes. This makes it difficult to give any accurate estimate of the number of feet of hole drilled per day per drill. Our representative at the blast was informed that when drilling was in favorable rock a 60-ft. hole was drilled in two 10-hour shifts, or 30 ft. per shift; but that in some cases, where the rock was very seamy, it was necessary frequently to throw small chunks of cast iron into the hole to prevent sticking of the bit, and then the drilling was much slower, occasionally as many as six shifts being required to drill one hole.

There were eight Ingersoll-Sergeant drills and two Sullivan drills, having 5½-in. cylinders, used on this work. Fig. 3 shows seven of the Ingersoll drills in a row. As seen in Fig. 2, each drill was mounted on wooden blocking bolted to two lines of sills bedded in the bottom of the pit. An extension chuck was used to facilitate the handling of the drill steels by giving plenty of clearance between the drill and the face of the rock ledge.

Reverting to the cofferdam, little need be said further than to call attention to it in Fig. 1. First a single line of cofferdam was built at low water; then a double line cofferdam, 16 ft. wide, filled with clay, was built farther out and holding against a 25-ft. head of water. Incidentally it may be added that the plan of driving a series of small tunnels from the pit inside the cofferdam was considered, but the idea was abandoned because of the seaminess of the rock.

We come now to the charging of the long lift holes with dynamite. At first some experiments were made with tin tubes containing the sticks of dynamite, but the tendency of these tubes to catch on irregularities in the sides of the hole led finally to the use of plain paraffined paper cartridges. These dynamite sticks were made by the National Powder Co., of New York, especially for this work. The sticks were 24 to 30 ins. long and in four sizes, to fit the taper of the drill hole, 2½, 3, 3½ and 4 ins. in diameter. About half of the 38 tons of dynamite was 60% grade, and the other half was 75%. Since it was expected that some of the dynamite would be under water three weeks before the firing of the blast, the manufacturers wrapped each stick with two layers of paraffin paper and afterwards coated the sticks with a paraffin composition. This, as the results of the blast demonstrated, was an effective waterproofing.

There were 900 electric exploders used, and these also were made especially for submarine work, the manufacturers being the Star Electric Fuse Works, of Wilkes-Barre, Pa. To fire the exploders there were used 110 volts and 75 amperes, the 900 exploders being divided into 45 groups of 20 each, these 20 exploders being joined in series. Each of these 45 groups was joined parallel to the main wires. By this method of wiring every exploder received 1½ amperes.

In addition to the 203 lift holes, there were a number of nearly vertical holes drilled at irregular intervals just inside the cofferdam; and, in the clay core of the cofferdam, holes were bored 10 ft. apart, with an earth auger, and charged with 30 lbs. of dynamite per hole, in order to insure complete destruction of the dam.

The firing station was located 1,000 ft. away from the nearest point of the cofferdam. The cofferdam was breached at low tide, in order to flood the pit and thus secure a water tamping, as well as cushion to take up the shock of the explosion. Even at high tide there were a few parts of the rock ledge visible, and apprehension was felt by some observers lest the heavy blast would hurl rocks to a great distance. As a matter of fact, when the blast was fired, at 4.10 p. m., sections of the cofferdam fell in the water at distances that appeared to be nearly 800 ft. away from their original position. However, there was not a sin-

gle accident to mar the enterprise, and the office buildings 300 ft. from the blast were unhurt. The shock was scarcely felt by those at any considerable distance, for the explosive appeared to have expended nearly all its energy in breaking rock. A huge column of water, timber and rock rose to a height of perhaps 150 ft., and at the same time a sort of "tidal wave" rushed across the narrow 800-ft. channel to a height of several feet.

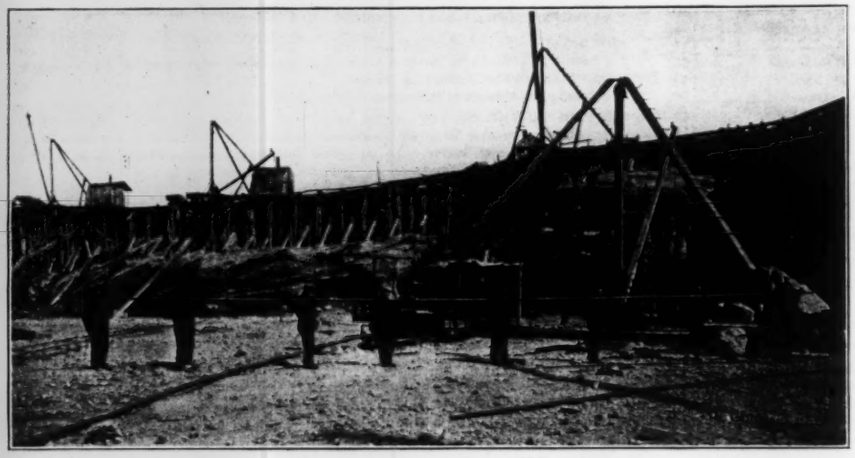

FIG. 1. COFFER-DAM AND INSIDE OF PIT, HENDERSON'S POINT, WITH EIGHT MEN CARRYING A DRILL STEEL 68 FT. LONG.

The $750,000 contract for this work was awarded by the Government to the Massachusetts Contracting Co., of Worcester, Mass., three years ago. Mr. O. A. Foster, as superintendent of the company, has had charge of the work for the contractors. It is his opinion that the blast was entirely satisfactory, and that the rock was so broken as to make the dredging comparatively easy.

Lieut. Luther E. Gregory, U. S. N., has been the engineer in charge of the work for the Government.

ASPHALT OR COAL TAR CONCRETE FOR BASEMENT AND GROUND FLOORS.*

By Edward Atkinson.†

It was formerly believed and still is believed in many cases to be necessary to put either a cellar under every building or else to construct a timber and plank floor above the level of the ground. Cellars are apt to be dark, unwholesome, and worse than useless under mills, workshops, tenements, and single dwellings. Spaces of irregular height under basement floors are almost invariably dark, damp, and are unwholesome reservoirs in which foul air is generated. The writer has had bitter experience in his own practice and has witnessed many cases of the rotting of timbers and plank in a relatively short period under these conditions. Such cellars and spaces are useless and noxious from every point of view and may never be tolerated unless rendered necessary for carrying shafting under the floors, usually a bad method. If such air spaces are provided they should be made as light as possible and should be ventilated, even if a forced circulation is required.

The true floor of a basement or of a one-story factory or workshop should be leveled up above the grade with gravel, sand or rubble, and should be thoroughly drained. On this base a thick coating of asphalt or coal-tar concrete should be spread. Trenches may be made in which timbers may be imbedded in such concrete. When a plank floor is required, it may be laid solid on the timbers with concrete, filled up and swabbed with coal-tar so as to make a complete contact with the under side of the wood and so as to envelop the timber. Wood laid in this way on asphalt or coal-tar products will last as long or longer than any other wood in the mill. We have examples which have been under our supervision for more than 20 years.

If only a solid floor is needed, without planking or timber, the concrete may be finished the same as sidewalks are now finished, and in some places concretes made with coal-tar products are proving to be extremely serviceable in place of pavement on roadways.

Since tank bottoms from the California oils and from coal-tar products have lately displaced asphaltum, as we are informed, the products of coal-tar are mostly in use in laying the floors. They are both antiseptic. They are non-heat-conducting, impervious to water, and are therefore warm to the feet.

Cement concrete, stone or artificial stone, are not advised for basement floors or for the floors of one-story shops. They contain water in a hygroscopic form. W[illegible] laid in or upon such concretes is quickly destroyed. Th[illegible] are ready conductors of heat and are therefore very c[illegible] to the feet. In many stages of the atmosphere they b[illegible] come absolutely wet, probably from the condensation [illegible] moisture from a humid, warm atmosphere.

*Abstract from report of Insurance Engineering Experiment Station, Boston, Mass.

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THE DEVELOPMENT OF SPECIAL TRACK WORK O[illegible] STREET RAILWAYS.*

By Victor Angerer.

Street railways and street railway engineering h[illegible] undergone a most marvelous development within t[illegible] last twenty years. Before that time there really w[illegible] no such person as a street railway engineer, and any o[illegible] who would have called himself a street railway engi[illegible] neer in those days would have been looked down u[illegible] by the engineering fraternity in general, somewhat a[illegible] sculptor would look upon a stone mason. Some o[illegible] engineers engaged in other lines once in a while m[illegible] have laid out a curve for a street railway. Then th[illegible] was the contractor, who laid down the roadbed in [illegible] city streets with flat rails rolled by a few rolling m[illegible] and there was the manufacturer of switches, frogs [illegible] curves for street railways, such as were used in th[illegible] days, and these were the engineers. The street railw[illegible] themselves, which were practically all horse railw[illegible] had a road master or trackman, but they had no engi[illegible] neer.

This is all changed now, and the great electric r[illegible] way systems of the country rival in importance the la[illegible] steam railroads. Street railway engineering has co[illegible] to be a profession, and the problems and difficulties wh[illegible] the engineer of way of an electric railway meets and ha[illegible] to overcome are at least equal to those of the engineer of way of the steam railroads.

I shall endeavor to show you some of these problems and how modern street railway methods have been developed in that particular small part of the permanent way known as "special track work," comprising curves, switches, frogs, etc., and how the engineer of way of a steam railroad is actually just commencing to profit by the demonstration of the success of these methods as employed by the street railway engineer of way and as developed by the manufacturer of such special track material.

It will be necessary for this purpose to give you a short history of the gradual development of special track work on street railways.

This development is marked by four distinct periods. In the days of the "corn-fed motor," prior to the year 1884, we have the "flat rail period." The track was laid with flat rails, spiked to a wooden stringer, which in turn was fastened to cross-ties, either directly by spikes, or by knees and spikes, the stringers being interposed between the rail and cross-tie, to give the necessary height for paving in city streets. For the curves a flat grooved rail, bent cold to the required curvature, was introduced in 1872 by Mr. William Wharton, Jr. Prior to that the curves were made of iron castings, in the shape of a grooved flat rail, but of course in short lengths, such as it was practicable to cast in the foundry. In some locations, particularly in New England, the grooved guard rail was only used on the inside of curves, while the outside rail was formed of a flat steel bar, on which the

*From a paper read before the Connecticut Society of Civil Engineers and Surveyors, and published in its Proceedings for 1905.

FIG. 2. A 5½-IN. ROCK DRILL, WITH EXTENSION CHUCK.

FIG. 3. SEVEN DRILLS, PUTTING DOWN HOLES 50 TO 79 FT. DEEP.

wheels traveled on their flanges, the guard of the inside rail guiding the car. The switches and frogs consisted of iron castings, sometimes chilled on the surface, with pockets on the ends to receive the adjoining rail. Under the light cars this kind of track gave quite good satisfaction and lasted for a long while.

Considerable ingenuity, however, had to be exercised even in those days to build some of the more intricate pieces of curve work. All the switch and curve work had to be made in such a way that it would not interfere with the team traffic of the city streets, and special means had to be employed to take care of the small flanges of the wheels and the narrow treads on street railway cars, which as a matter of fact have not changed to the present day, and it is just these narrow wheels and small flanges that brought about the subsequent revolution in the construction of special track work, as I shall explain somewhat more fully further on.

The drawback to the old flat rail system was particularly that the wooden stringers became rotten in time and the joints of the rails battered down into the stringer. The cars also became somewhat larger and heavier, and this led to the introduction of the girder rail on street railways, and we have the second period, i. e., the "Early Girder Rail Period," from about 1884 to 1891. While the first girder rail was laid in San Francisco in 1877, these rails did not become generally known until in the early 80's. The Johnson Steel Street Rail Co. made a specialty of rolling them, closely followed by the North Branch Steel Co., controlled by William Wharton, Jr., & Co. The rails weighed from 35 to about 65 lbs. per yd., were of a section both with and without a base; they were mounted on chairs of various descriptions, which in turn were spiked to wooden cross-ties, thus doing away with the wooden stringer. The special work consisted of curves bent from rolled rails corresponding in general form to the girder rails used in the straight track, but provided with a guard to guide the car wheels—in short, girder guard rails. The switches, frogs and crossings were of several distinctive kinds. First, built up of pieces of girder rail, planed and shaped to suit, and then riveted or bolted together, following out the idea of adapting to the street railway track the practice of steam railroads in the construction of frogs; but it soon became apparent that they were not well adapted to street railway track, in that the bolts and the rivets, becoming loose, and not being accessible, as in steam railroad track, to receive the constant attention and tightening up that steam railroads give to their frogs and crossings, but being buried in the pavement of the city street, could not get the proverbial "stitch in time" and the work, under the action of both the team and car traffic, shook apart before being worn out. Then, we have switches and frogs of chilled cast iron, similar to those of the old flat rail period, but also mounted on chairs, instead of the wooden stringer. These gave good satisfaction, except the joints, which were not in keeping with the rest. We further have work similar in construction, but lighter and made of cast steel or Mitis steel, but this in those days proved too soft or too porous to warrant the greater cost.

The cable railways and electric railways which then commenced to be established throughout the country soon demonstrated that neither of these constructions was adequate for the much heavier cars, and we come to the third period, or what I may call the Intermediate Girder Rail Period, from about 1891 to about 1895. The chairs under the rails are abandoned and the height of the girder rails is increased, up to 9 ins., so that they could be spiked directly to the ties. For curves, guard rails of similar outline are used. The problem of the construction of switches, frogs and crossings was attacked in different ways by the various manufacturers, and we have again several distinct types, of which I will mention:

First, steel castings, somewhat improved in quality but still softer and more porous than the rolled rail.

Second, steel castings with pieces of the rolled rail electrically welded to the ends, to overcome the objectionable inaccurate fit of the joint plates on the ends of the first kind.

Third, chilled cast iron, with rolled rails cast into the ends, with the joints, therefore, as good as in the rest of the track, but while hard, still brittle, and therefore subject to spawling.

Fourth, rolled rails, planed and fitted similarly to the built-up work, but instead of being bolted or riveted together, they were united by molten iron being run through and around the rails, eliminating the disadvantage of the bolted work, and at the same time giving the same metal, i. e., rolled steel rail, on all surfaces throughout the special track work.

Fifth, a combination of the cast-iron and rolled rails, somewhat similar to the fourth kind described, but with the cast iron in some parts exposed to the wear.

I will not go further into the relative merits or demerits of these various types, of which some are still used in places where the traffic is so light that it does not warrant putting down a more expensive style of work. They all have one common point of weakness—the parts which receive the greatest wear, where the same surface has to bear the traffic of more than one line, or where a narrower surface than the width of the wheel tread has to support the weight of the car, naturally wear down much faster than the rest of the work, and when the wear of these parts becomes objectionable, the entire piece has to be renewed. This weakness is inherent to all frogs, also steam railroad frogs, built up of ordinary rails, but is immensely accentuated on street railways by the narrower wheel treads which the street railways are compelled to use. The width of the wheel tread cannot be wider than the width of the head of the rails, without danger of striking projecting paving stones on the outside of the rails, and the width of the head of the rail is in many cities restricted by ordinance, mostly dating back to the old horse-car times. This width of tread is insufficient in many cases to span the groove of an intersecting track at the point of a frog or of the main track in branching off at the point of a mate. It therefore has always been considered advisable, in fact, almost necessary, in street railway work, to provide at intersecting grooves, a riser, or flange bearing, i. e., the groove is filled up at its bottom, so that the flange of the wheel will bear on this filler and the wheel run on this flange where it theoretically loses its tread bearing. In castings, the metal of the casting itself is carried up; in built-up work separate pieces of metal are inserted, or the work constructed from specially rolled rails with shallow grooves. But the surface of the flange of a wheel presents a cutting edge rather than a bearing surface, and consequently these risers in work of the kind mentioned are soon cut down and then the wheels commence to pound and quickly destroy the parts where they have such an insufficient bearing, or where they have to jump across the space of the intersecting grooves.

To protect these parts was the simultaneous thought of several manufacturers. This led to what has been known for the past ten years as "hard center work" and we have the fourth period, the Hard Center Work Period. Two principal ideas were followed out in working up this problem. The one was to provide a separate comparatively small piece or plate, commonly termed the center, at these points of greatest wear, which, when worn out, could easily be renewed without disturbing the rest of the work. Incidentally these centers were made of a somewhat harder metal than the surrounding parts. The body of a frog is made of cast steel, with a recess in the center, into which is set a plate of Harveyized steel, with the grooves planed out before Harveyizing. The sides of the recess are undercut, and the sides of the plate beveled, or provided with projections, and zinc, or similar metal, is run into the space between the plates and the recess, forming a key to retain the plate in place. By chipping or melting out the zinc key, the plate can be removed. This zinc key, in practice, did not prove quite sufficient to hold the plate, and was subsequently supplemented by various other holding devices, such as wedges, bolts, etc. The body of these frogs is sometimes made of cast iron, instead of cast steel, with rails cast into the ends, in conformity with the method described in the earlier girder rail special work, without hard centers. The Harveyizing, of course, makes the surface of the center harder than the surrounding parts. This hardness, on a sample which I have here, penetrates to a depth of somewhat less than ¼-in. Below that thin hard shell, the metal is quite soft, as can easily be ascertained by a drilling test. In another method the center, made of tool steel, chrome steel, or some other harder steel than the surrounding parts, is simply bolted down, so that it can be renewed by unscrewing the bolts. The objections to the bolted-together work pointed out in the other periods apply to this. These are only some samples, as a great multitude of methods of fastening the centers into the pieces were designed and put into use.

Of the metals mentioned, I have here samples of chrome steel in the natural casting, which appears rather soft and quite porous. A forged piece of the same metal shows greater density, but is still not so very hard, and while it has considerable strength, is rather brittle. The regular carbon tool steel is of course known to all of you, but if made quite hard it becomes brittle, and in the large, irregular mass of a center does not seem to lend itself well to thorough and uniform hardening.

The other idea in hard center work was to, if possible, provide a metal in these centers which would so much better resist wear that the parts made of this metal would remain serviceable as long as the surrounding parts, made out of the usual Bessemer rail. For example, the center of a frog consists of a piece of Tungsten steel, i. e., self-hardening tool steel, which is placed right in the mold in the foundry, and the cast steel, forming the frog or other special piece, is cast around it. In cooling and shrinking it secures the center permanently into the structure. The metal, being self-hardening, does not lose its hardness through the heating it receives in the mold. Tungsten steel is susceptible to being made very

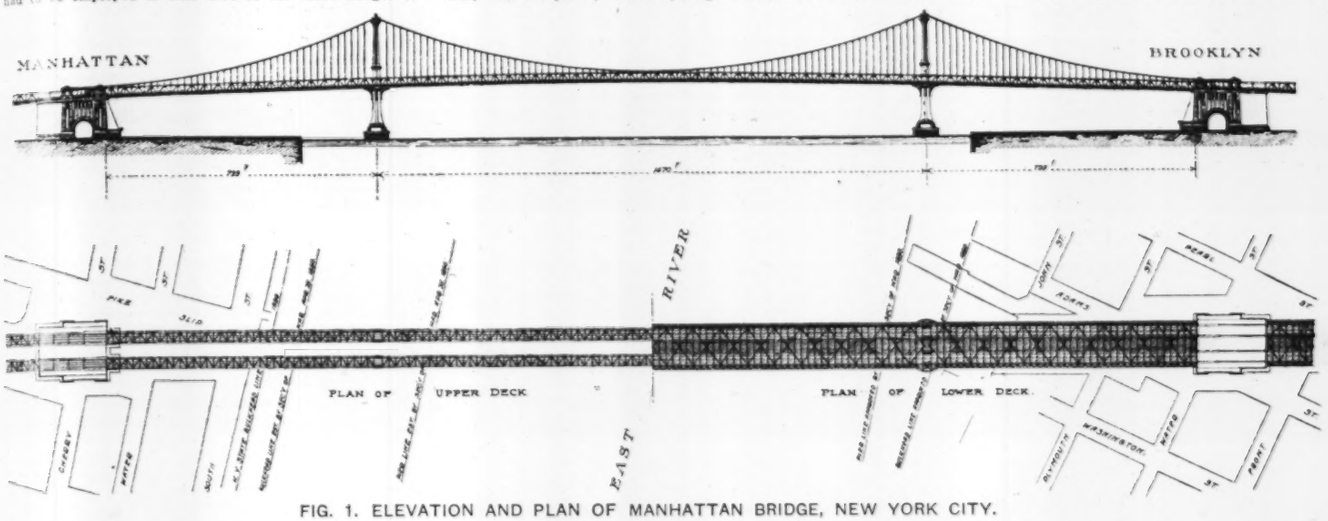


FIG. 1. ELEVATION AND PLAN OF MANHATTAN BRIDGE, NEW YORK CITY.

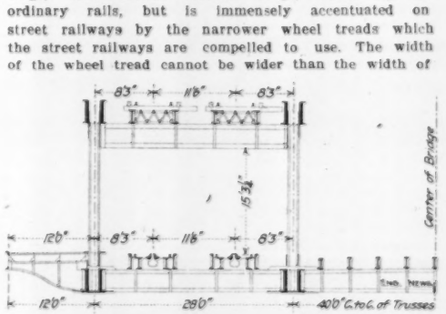


Fig. 2. Half Cross-Section of Manhattan Bridge.

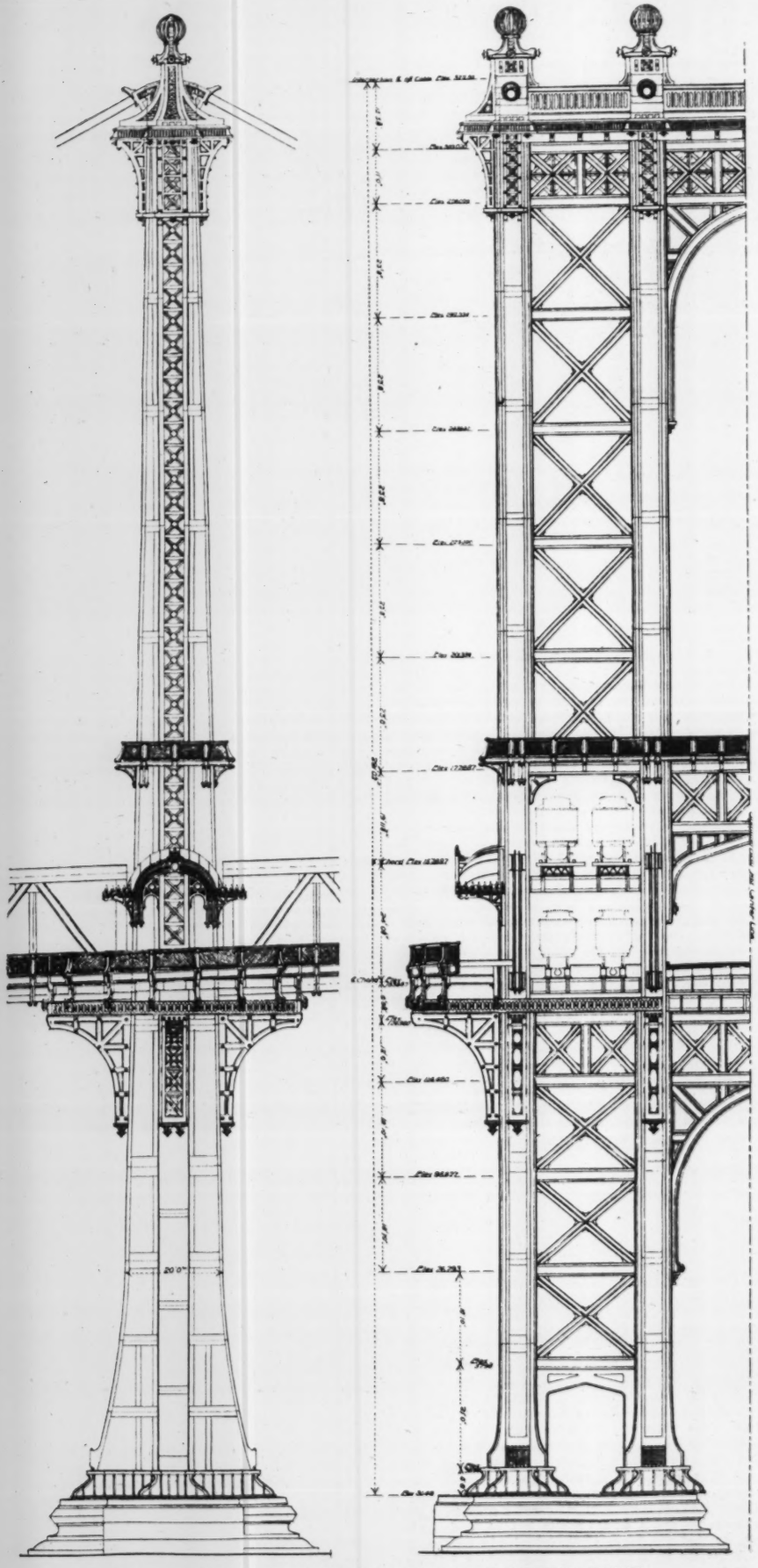


FIG. 3. GENERAL ELEVATIONS OF TOWERS, MANHATTAN BRIDGE.

hard, which led to a trial of its use for the purpose described. It is, however, very brittle, and sensitive to shock.

Another method is to produce a frog or other special piece with a recess for the reception of the center, carefully machine both and then, by heating the main body to expand the recess, insert the center and let the main body shrink onto the center, similar to the manner in which a steel tire is shrunk onto a wheel. Some metal that is machinable must of course be used for the center in this method.

A method which I should also mention by which the manufacturer seeks to accomplish the object of protecting the points of greatest wear without the use of a special center, is the Harveyizing locally of the surface of those parts in ordinary steel castings which constitute such pieces.

A method, in which incidentally there is a possibility of renewal of the center, but which really belongs to the second category, consists of a center of manganese steel provided with lugs, which project through the main body and by which the center is securely anchored down by means of heavy keys or wedges driven through openings in the sides of the body. A bed of zinc is interposed between the center and the main body, to insure a solid bearing throughout. The body of the pieces is made of cast iron or cast steel, with rails cast in the ends. The renewal of the plates necessitates the removal of the paving blocks, to get at the openings in the sides to drive out the keys, after the bed of zinc is partly melted out; but as it is the intention that such renewal should only be necessary in case of accident to the center or the development of a hidden defect in same, this does not present any serious difficulty. In a recent modification of this type of work, large bolts and nuts are employed to hold the center down, instead of lugs and keys. These bolts and nuts are entirely surrounded by zinc, which also forms the bed, in order to keep them from turning and rusting. The renewal of these centers, should it become necessary for any special cause, can be accomplished without the removal of any paving blocks, by melting or chipping out the zinc around the bolt heads and unscrewing them with a socket wrench.

Of all the various metals mentioned, I believe manganese steel, when properly treated, is to-day generally recognized as the best known metal for the purpose described, and by its use the idea of making parts of greatest wear last as long as the adjoining rails has been practically carried out.

Manganese steel was invented or discovered by Mr. R. A. Hadfield, the great iron master of Sheffield, England. He confided his patent rights and processes for use in the United States to the Taylor Iron & Steel Co., of High Bridge, N. J. William Wharton, Jr., & Co., Inc., after experimenting largely with different metals, recognized the value of manganese steel for the purpose, and acquired the right for the use of the Hadfield manganese steel, made by the Taylor Iron & Steel Co., in track work. Mr. Hadfield discovered that an alloy of manganese and steel, containing over 6% and less than 20% of manganese, possessed the remarkable property that, while already very hard, when heated to a high temperature and suddenly cooled by plunging in water, it, in exact reverse to the action of the usual hard steels, became more ductile and tougher, without losing its inherent relative degree of hardness. This combination of hardness and toughness, produced by the treatment, when in proper relation, produces its great wearing qualities. This treatment of heating and plunging in water may sound very simple, but the proper and uniform development of the properties of manganese steel mentioned to produce the highest and best combination of hardness and toughness suitable to each purpose, forms the most important part of Mr. Hadfield's invention. Besides being covered by numerous patents, the proper treatment of manganese steel is in itself an art, which can only be learned by years of experience. The first patent of Mr. Hadfield, simply covering an alloy with the percentage of manganese stated, has expired, and therefore anybody can make the alloys, but if not properly treated it loses its value for the purposes mentioned. In the untreated state manganese steel castings, while already very hard, are brittle. When treated, it will bend and twist readily cold without fracture, and at the same time will be so hard that a good new drill will hardly make an impression on the metal. The metal is exceedingly difficult to handle in the foundry. It is extremely hard, its shrinkage is enormous compared with ordinary steel, making the production of intricate castings quite a problem. Its ultimate strength is very great, and after proper treatment it gives a most remarkable elongation of specimens under test. The drawback to its more general use for various purposes is that it cannot be machined, and all finishing has to be done by grinding with emery wheels. There are many articles in which manganese steel is used with great success, such as stone crusher jaws, dredger pins and points, screens for coal mines, mine car wheels, etc., and of late years for burglarproof safes and vaults, with which some remarkable tests have been made, the safes proving practically entirely dynamite proof.

Hard center work in street railway special work to-day is practically the standard, and no street railway I believe would consider the use of anything else in important and complicated layouts. In connection with this, it might interest you to compare prices and length of wear of the constructions of the various periods. Work of what I call the second period, i. e., the early girder rail construction, was installed at a certain place in the summer of 1890. The material weighed 82,500 lbs. and cost in round figures $3,100, or an average of 3¼ cts. per lb. It was worn out and renewed with work of the third period in the spring of 1893, having lasted about two years and nine months. The material in this layout weighed about 100,000 lbs. and cost a little less than $5,000, or 5 cts. per lb. It lasted until the summer of 1897, a little over four years. It was replaced with manganese steel hard center work, which has been in service ever since, with the exception of a few centers and about three or four pieces out of a total of 76 pieces, which were renewed within a year or so. This layout has, therefore, lasted so far nearly 7½ years, a gain of nearly 100% in the service obtained. The material weighed 142,500 lbs. and the cost in 1897 was about $5,700, or only 4 cts per lb., notwithstanding the expensive metal used in the centers. However, 1897 was a year of cheap material. Pig iron was then $11 to $11.50 per ton. T-rails sold at $20 per ton at the mill, and girder rails at $24. To-day this layout would, on account of the use of a heavier rail and some strengthening of the pieces, weigh about 155,000 lbs. and cost about $7,700, or a little less than 5 cts. per lb., an increase of 25% over 1897, while in raw material, pig iron increased 50% to $16.50 or $17 per ton, and T and girder rails increased 40% to $28 and $34 per ton, respectively.

I am often asked how long such a piece of work should last. It is impossible to name a time. It depends on the amount of traffic, on the conditions of traffic, weight of cars and passengers, speed, weather conditions, tendency of the wheels to slide or turn at some points, and no uniform base can be established. I have tried by careful measurements of impressions taken of track in the street to average the wear of manganese steel centers per car, but had to give it up. The results I obtained varied from .0012-in. to .0020-in. of vertical wear per ten thousand cars. Mr. Hadfield, in making similar tests, observed a vertical wear of from .008-in. to .0023-in. per ten thousand cars, at different points of one layout. Variations amounting to from 100 to 200% of course do not admit of any conclusion. A difference of opinion also naturally exists as to when a piece of special work should be called worn out. I have a photograph of a center which was taken out after 2,570,000 electric cars had passed over it, and it does not seem to be worn very much.

The manufacture of street railway special track work requires an enormous amount of detail work, of which no one who has not visited such a manufacturing plant has any conception. As the curves are usually very sharp, so that the rails cannot be readily bent on the ground, the intersections and special pieces come close to each other, requiring a large amount of cutting of rails, it is the general practice to fit every piece of special track work for street railways together in the shop complete before shipment. The making of the working plan of such a layout involves intricate calculations and a careful consideration of all conditions. As it finally passes into the hands of the track layer, it must contain data for properly locating the work in the street, as well as for the fitting of the work in the shop. The lines of the curves in modern special work are no longer plain circular curves, as they were in the "corn-fed motor" times, but easements or spirals are introduced at the ends of all curves, to insure the smooth running of the cars and obviate the shock that was experienced from cars entering short circular curves. These easements or spirals usually consist of a number of sections of circular curves, increasing in the radius towards the tangent point, in imitation of a parabola. This, however, has to a great extent been overdone.

Each manufacturer and many of the large street railways have systems of their own, in regard to spirals, requiring different calculations for each one to apply them to special work layouts, while practically, when laid down alongside of each other, the lines of these different spirals for a given curve vary less than ¼-in. at any one point. Some uniform standard in street railway spirals is badly needed.

When the special track work of a street railway is further complicated by the introduction of a slot for the admission of a grip or electric plow, as for street railways with a cable or electric conduit, then its manufacture becomes intricate indeed. As cable railways were already introduced more than twenty years ago, the track part of conduit railway special work underwent the same stages as the work for the street railways without conduit.

Cable railways, however, are practically a thing of the past. They were soon followed in cities like New York and Washington, where overhead trolley wires were not allowed, by the conduit electric railways.

The installation of complicated special work layouts in the street presents many difficulties, particularly in busy cities. The street and car traffic must not be interfered with. The space of time between cars is usually so short that no attempt can be made to install a layout during the day.

The handling of the very heavy and bulky pieces is sometimes very difficult by the limited means allowable on the street, and in view of the ever increasing weight of such pieces, the street railways have also come to the use of wrecking cranes.

With conduit special work, the difficulties of installation becomes still greater. As it takes of course longer to put it down, no chance can be taken of any delay, and very often it is considered advisable to again set up the entire layout on the street before putting it in place.

The greatest difficulty in the proper designing of special work for street railways lies in the fact that there is no standard in the sizes of wheel treads, wheel flanges and wheel bases of cars in use, and yet each of these factors, combined with the radii of the curves, calls for a different width of groove, and the depth of the groove at the intersections. The tendency of wheel makers has been to increase the thickness of the wheel flanges of a given depth, which has proven very troublesome in the making of special track work.

Not only are different wheels used in different cities, but very often cars with widely different wheels are run over the same track. That it is impossible to make special track work to suit such conditions will be obvious. I am not now referring to the problem which has developed of late years of running suburban cars, which for their speed are equipped with larger flanged wheels, over the tracks in the hearts of cities, which are built to receive the smaller flanged wheels usually necessary to comply with city regulations. This is a problem for which the solution has not as yet been found. It may lie in wider wheel treads for both the city cars and the interurban cars, but for that the tracks throughout the city streets would have to be equipped with a rail that would admit of wider wheel treads. Some cities, like Philadelphia, have made a start in that direction. It may also involve deep but thin wheel flanges for both kinds of cars, with the wheels probably made of cast steel instead of cast

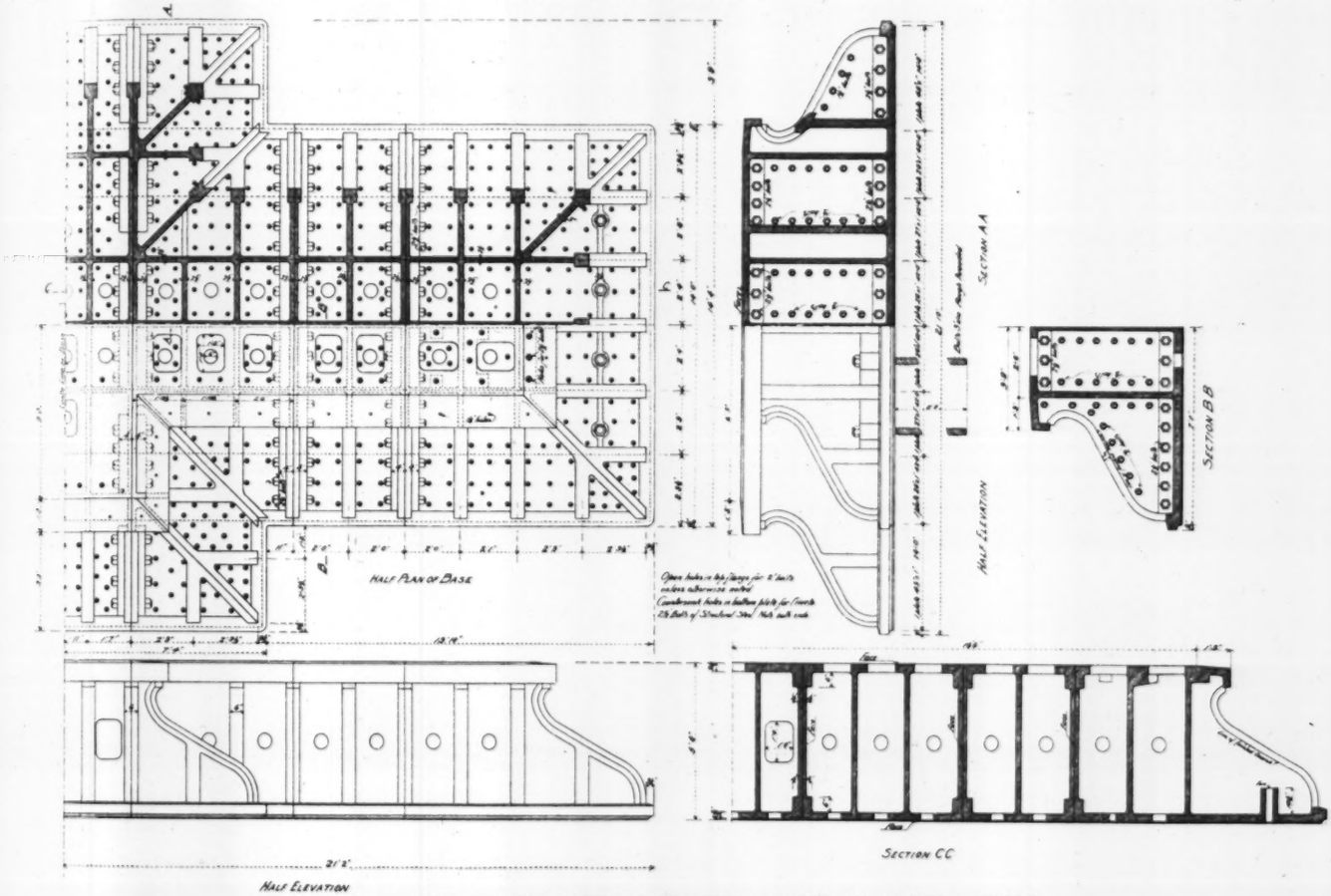


FIG. 4. DETAILS OF BASE CASTINGS FOR TOWER LEGS, MANHATTAN BRIDGE.

iron. Another great difficulty lies in the lack of standards in the sections of girder rails used on street railways. Nearly 100 different girder rails are now rolled, and many obsolete sections which are now not rolled are in use in addition to these. One quarter of the number of sections shown, I think, would cover all requirements, and satisfy all city regulations. The street railway engineers in that respect have not learned and profited from the steam railroad engineers, and have not as yet done for the street railways what the American Society of Civil Engineers has done for the steam railroads, in regard to establishing standards of rail sections.

On the other hand, the steam railroads have profited by the experience of the street railways in regard to methods to increase the life of their special track work, i. e., their frogs and crossings, and will profit still more when the success of the application of these methods to steam railroad frogs, crossings, etc., becomes more widely known. I refer to the employment of a harder and more

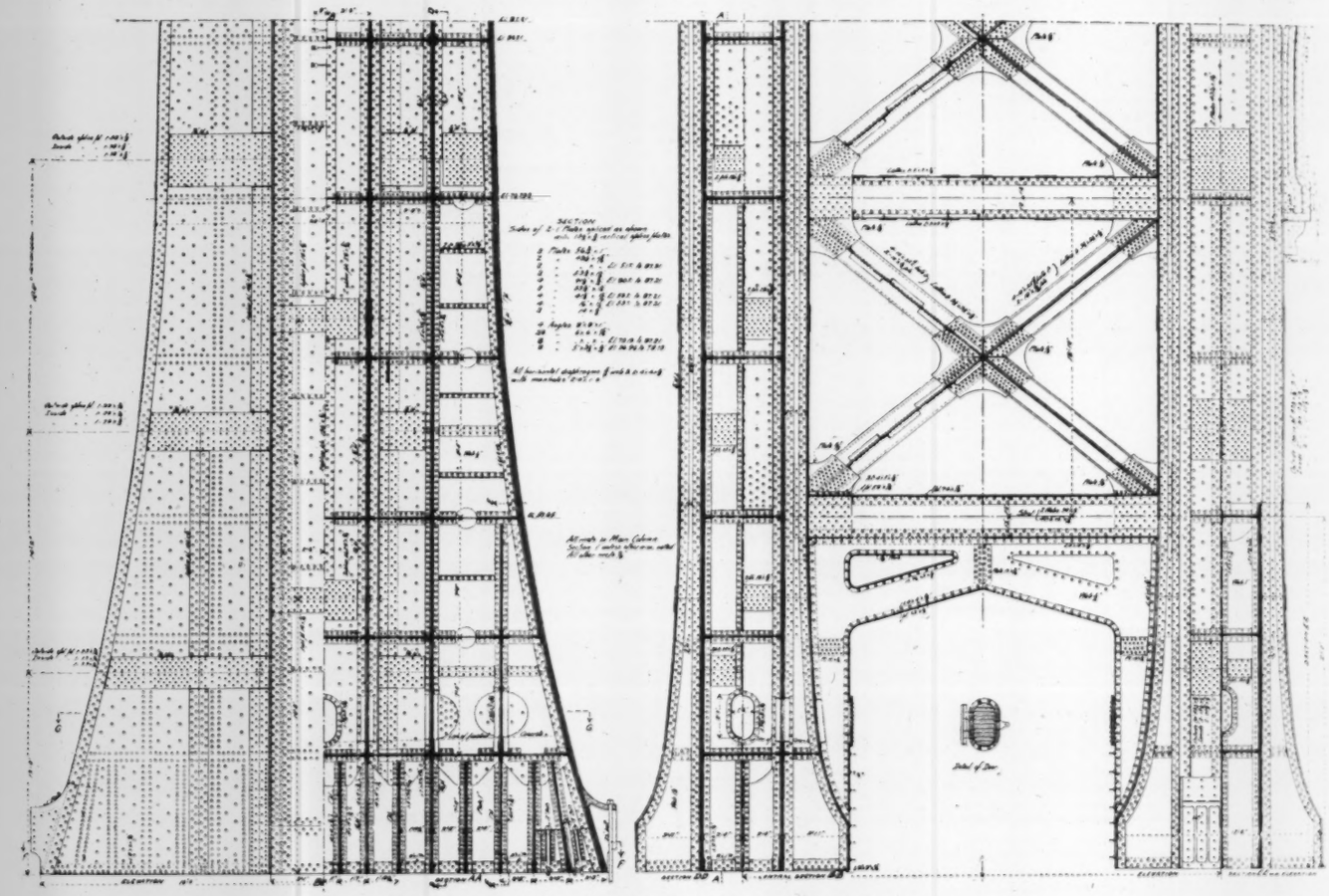


FIG. 5. BASE SECTION OF TOWERS, MANHATTAN BRIDGE.

durable metal in the vulnerable parts, which in these frogs and crossings give out first. In steam railroad tracks, in city paved streets, they adopted the methods of the street railways outright, including girder rails, of a suitable heavy section, and special track work made exactly like that for the electric railways, only somewhat heavier.

The first step in that direction in regular high speed track was the introduction of what is known as "anvil face" frogs, in which pieces of a harder metal are set into the wing rails, which are usually cut out first by the action of the wheels. In the next stage, some steam railroads were directly induced by the street railways to try the use of a harder metal, like manganese steel, to a greater extent in crossings of electric railways over the steam roads. Such crossings are usually made by being built up of numerous rails, the steam railroad track consisting of the running rail, an auxiliary or easier rail on the outside of that, to prevent the blow of the overhanging wheel treads to the crossing rails, a guard rail and a filler between the guard and main rails. The engineers of the Philadelphia Street Railway system suggested that instead of these many parts, a single manganese steel casting, combining all these rails and fillers in one piece, should be used. The engineers of the two principal steam railroads entering Philadelphia were naturally and rightly cautious in adopting such a suggestion, but after witnessing a number of extremely severe tests of the metal, they felt safe in allowing its use under the heavy loads and high speeds of their trains. These crossings, proving eminently successful, finally led to the trial of manganese steel in regular steam railroad frogs. A test frog, cast solidly of manganese steel, was put into the tracks of the Pennsylvania railroad at Philadelphia on March 11, 1900. It remained in service four years and forty-seven days, until April 27, 1904, in a place in which the maximum life of an ordinary steel rail frog had been determined to be not more than three months. The frog was then worn down at the point about $\frac{5}{16}$-in., but the rails on the end were worn considerably. Allow me to tell you about a remarkable feat which was then accomplished with this frog. After being taken out it was sent back to the shop, new rails were fitted into the ends, the central part was then bent up to the extent of the vertical wear, in a powerful hydraulic press, and the entire surface was ground level, at a comparatively small cost. The frog was then as good as new, and was put back into the track in the same place on June 20, 1904, and is of course still in use. There are now over three thousand of these manganese steel frogs in use on the Pennsylvania Railroad and many other railroads of the country, besides many crossings.

In the meantime the elevated railways, especially the Boston Elevated Railway Co., had taken up the use of manganese steel in some of its special track work. The conditions of wear on the Boston Elevated Railway were most remarkable. Some curves made of 85-lb. T-rail wore out in 40 days. The wear on frogs and crossings was equally severe, and, as can be imagined from the wear stated on the curves, was not confined to the points and wings of the frogs, but extended over the entire surface. Therefore it was not a question to make simply these points or portions of a frog of manganese steel, but the entire frog had to be made of that metal. Crossings had to be similarly constructed. Finally the Boston Elevated Railway approached William Wharton, Jr., & Co., Inc., in regard to the making of manganese steel rails for some of their curves. After some experiments, such rails were cast, not rolled, but cast in 20-foot lengths, somewhat heavier in the section than the ordinary rolled rails, so as to make the casting possible, and a curve was put in of this rail near the Park St. station, in the Boston Subway. I take the liberty of quoting from a paper read by Mr. Steward, roadmaster of the elevated system of the Boston Elevated Railway, before the New England Street Railway Club last October. He says:

On this curve, ordinary rail had been in the habit of wearing out in about 44 days, measurements showing the wear of from .051 ft to .064 ft. in that time. The manganese steel rail was put into the track in April, 1902, and is still in. It has been in place nearly one thousand days, and shows a top wear of only about .016 ft.

The price of this manganese steel rail was more than ten times that of ordinary curved rails, but in view of the above result no comment is necessary as to the question of economy. There are now about 500 ft. of manganese steel rail in use on the Boston Elevated Railway. Before putting this manganese steel rail into service, some of the rails were subjected to remarkable tests. A rail was curved cold to 20 ft. radius. Half of this rail was then straightened out again, and curved the reverse way again to a radius of 20 ft., and the other end was curved down to a radius of 10 ft., and there was not the least sign of fracture.

These remarkable results have induced the Pennsylvania Railroad to also experimentally try manganese steel rails, and an interesting comparative test is about to be made by them, for which the rails have been delivered.

The principle of protecting the parts subjected to the greatest wear in track work by a hard metal is being applied to various portions of steam railroad special track work, made possible, of course, through the combination of hardness with toughness, as represented by manganese steel. A trial with split switches with manganese steel points is now going on, also manganese steel points for movable point-crossings.

For some time guard rails opposite frogs have been provided with manganese steel facings; also some solid manganese steel guard rails have been put into use, and there are no doubt other numerous applications which will gradually develop.

In the general application and development of this principle, and in the testing out of the various metals for the purpose, the street railways were undoubtedly the pioneers, and I believe that I did not say too much by asserting that the steam railroad engineer of way has profited by—using the term in a double sense—the street railway engineers' "special work."

THE STEEL SUPERSTRUCTURE OF THE MANHATTAN BRIDGE.

Plans have been made public and bids asked for the construction of the steel superstructure of the Manhattan Bridge at New York city. The work as planned consists of two steel towers, four suspension cables with their suspender systems, four stiffening trusses with their connecting platforms and lateral systems and two anchorage systems. The anchorage systems consist each of four cable anchors, four stiffening truss anchors, one wind anchor and two foot-bridge anchors, the last being for use during construction only. The steel work for the anchorages was illustrated in our issue of Dec. 22, 1904, when the anchorages were described in detail. The accompanying drawings show the remaining parts of the steel superstructure.

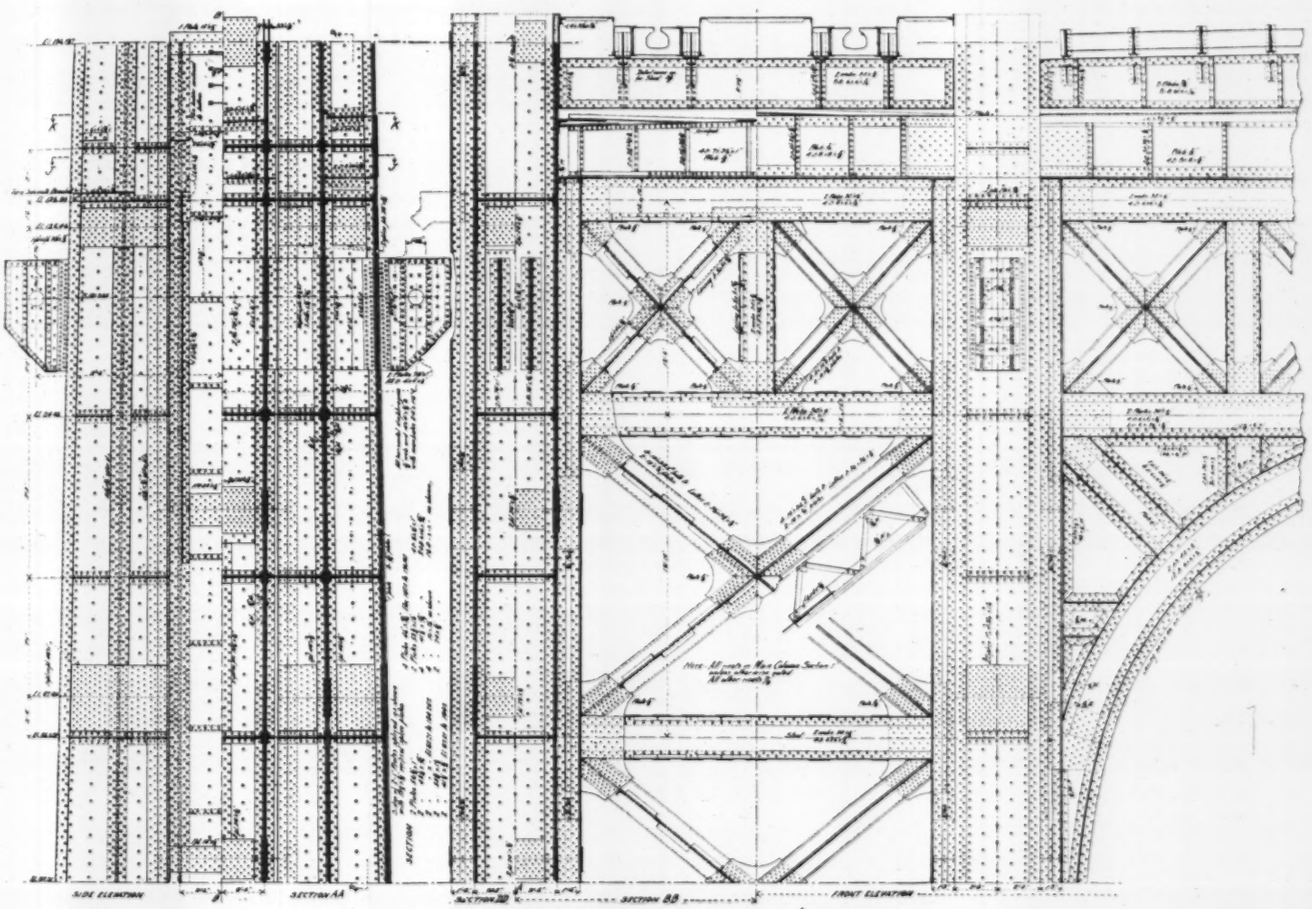


FIG. 6. ROADWAY SECTION OF TOWERS, MANHATTAN BRIDGE.

GENERAL DESCRIPTION.—The Manhattan Bridge, as has been stated a number of times in these columns, will cross the East River at a point just above the present Brooklyn Bridge. It is a wire cable suspension bridge of three spans, one center span of 1,470 ft. and two side spans of 725 ft. There are four cables each supporting a stiffening truss by means of suspenders. Other general information is furnished by the plan and elevation, Fig. 1, and the diagram cross-section, Fig. 2.

TOWERS.—The towers consist of four posts arranged in line transversely to the axis of the bridge. In this line the spaces between centers of legs are 28 ft., 40 ft. and 28 ft. The legs are braced together from top to bottom across the 28-ft. spaces, and at three points across the 40-ft. space, namely, just below the main floor, above the roadways to form portals and at the tower tops. Fig. 3 shows this general arrangement clearly.

Taking up the towers in detail we note first the base casting, Fig. 4. This is of carbon steel and is cast in sections which are connected by splice plates and bolts, as shown by the drawings. The base sections are also connected together on the bottom beds by a 1-in. steel plate riveted to the bottom web. The assembled casting rests on a 1-16-in. sheet of lead on the masonry and is connected to the masonry by eight 3-in. diameter 12½-ft. anchor bolts cemented into the stone work. When finally set, the cells in the base casting will be filled with concrete or cement grout, as indicated on the drawings, and all exposed faces finished with a 2-in. layer of 1 cement, 3 sand mortar. The concrete filling will be a mixture of 1 part cement and 5 parts gravel.

The steel-work of the towers above the base plates is shown clearly by Figs. 5 to 11, inclusive. These illustrations call for very little explanation. As will be observed from Fig. 5, the bases of the legs are filled with concrete to a height of about 8 ft. Figs. 10 and 11 show the horizontal bracing connecting the tower legs at the roadway level and near the tops of the towers. The horizontal bracing at the balcony level is much similar to that shown by Fig. 11, and is covered with steel plating to form the balcony floor. The specifications require that the main plates of the tower legs shall be planed or milled on all four sides. The horizontal joints shall be milled with great care so as to have perfect contact throughout and be perfectly normal to the axis of the tower, the vertical joints shall be planed before assembling so as to have a space of ⅛ in. between adjacent plates. All the steel is carbon steel.

SADDLES.—The cables are supported at the towers and anchorage by cast-steel saddles. Fig. 8 shows the tower saddles in sufficient detail. The anchorage saddles are shown by Fig. 12.

CABLES AND SUSPENDERS.—The suspension cables and suspenders are shown by Fig. 13. As already stated, there are four cables, each having the following lengths at mean temperature and without superstructure load:

Center of end pier to center of tower	857,358 ft.
Center of tower to center of main span	754,743 ft.
Half length of cable	1,611,801
Total length of cable	3,223,602

The other details of the cable construction are given in the following excerpt from the specifications:

There will be four steel cables approximately 20¾ ins. in diameter. Each cable will consist of 37 strands and will contain 9,472 parallel wires of 192-1,000-in. in diameter before galvanizing and not more than 197-1,000-in. in diameter after galvanizing.

In the operation of cable making each strand will be built several feet higher than its final position when laid in the cable. This will be accomplished by placing the shoe at each end of the strand, a fixed and previously determined distance back of its final position and also by carrying the strand on sheaves above the grooves of the cable saddles on tops of the towers and at the anchorages. When the strand is finished it will be lowered into the saddle grooves, the shoes will be placed on the permanent pins at the ends of the anchor chains and the strand will then be adjusted to its proper versed-sine by means of fillers between the shoes and the pins.

When all the wires of a strand have been laid in place and before the strand is placed in its final position in the cable, it will be bound together by bands to keep the wires in their proper position. These bands will be composed of five or six turns of No. 10 wire securely locked and will be placed at intervals not to exceed 5 ft. For the ends of the strands within the anchorages these bands will be permanent and must be placed about two feet apart.

During the operation of cable stringing the running wires shall be protected from abrasion by suitable rollers where this is liable to occur.

As the cables of this bridge will be much larger than any previously built, it will be necessary to assemble the strands in two or more groups; first the seven strands forming the center of the cable shall be consolidated and rounded into a core cable by removing the temporary wire bands and squeezing the wires of these core strands

together by heavy pressure bands and then winding this core with several turns of No. 16 plow-steel wire at intervals of not more than 10 ft., so as to secure the wires of the core cable together permanently in their true position. Second, a group of the twelve next outside strands shall be assembled uniformly around the core cable and rounded and compacted about this core by heavy pressure bands and then this enlarged core cable shall be wound with fine plow-steel wire as before. Finally, the remaining eighteen strands will be assembled about the enlarged core in a similar manner and securely wrapped into the final cable with No. 8 gage wrapping wire bands placed about four feet apart. The cable wires must be laid parallel and free from laps and must be so maintained throughout the work.

When each cable has been fully compacted and banded, the cast-steel suspender bands will be accurately placed and thoroughly clamped and the suspenders will be put in place. Before bolting on the cable bands, the cable under the bands shall be thoroughly cleaned of oil and

for the use of four supporting cables, each composed of four wire ropes.

At the tops of the main towers tie-beam saddles are shown on the detail plans, providing for making the land span and main span foot-bridge cables independent of each other; however, if contractor prefers, the foot-bridge cables may be made continuous from end to end, and supporting saddles with suitable clamping devices be used in place of the tie-beam saddles before mentioned

The foot-bridge platforms except over the main towers may be made of timber, but all platforms and framing on tops of towers, and wherever at the anchorages it is practicable to avoid the use of timber, shall be made of metal.

During the construction of the cables, if it is found necessary on account of exceeding the frictional resistance of strands in the saddles at the tops of the towers, or for any other reason, the balance of the horizontal components of stresses in main and land span cables shall be approximately maintained by bending the tops of the towers landward a sufficient amount for this purpose.

seized, the wires shall be spread apart as much as practicable and thoroughly covered with cable shield.

Again as each group of strands is bound together permanently in the cable the wires shall be thoroughly slushed with the cable shield.

When all the strands of the cables are finally bound together the surface of the cable shall receive a final coat of cable shield.

As fast as the strands are finally bound together in the completed cable the part of the cable so bound shall be thoroughly protected from the weather by a temporary covering, of material and form approved by the engineer.

The completed cable shall be temporarily seized between the cable bands at intervals of not less than 4 ft. the cables at each point before seizing being squeezed together as tightly as possible with powerful clamps.

The cables shall not be finally served until the suspended superstructure is completed and most of the dead load is applied. The serving shall be so done as to se-

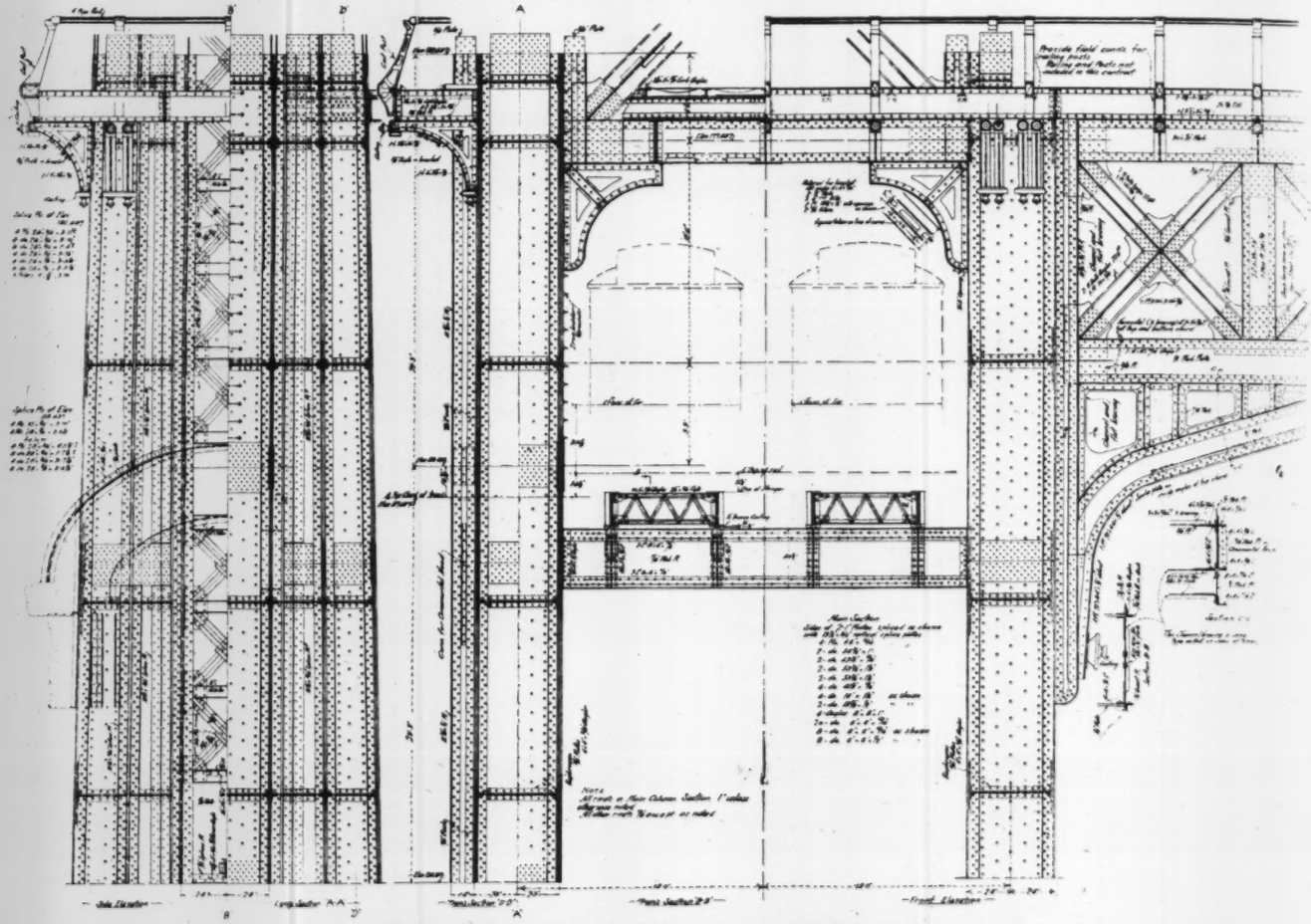


FIG. 7. PORTAL SECTION OF TOWERS, MANHATTAN BRIDGE.

receive a thorough coat of red lead paste. The temporary foot-bridges or working platforms used in constructing the cables may then be removed, so that contractor can proceed with the erection of the floor and stiffening truss spans, leaving the wrapping, painting and finishing of the cables to be done after the erection of the superstructure.

The final protecting covering of the cables will consist of a continuous serving between the cast-steel cable bands of galvanized round Norway iron wire applied under stress following immediately a thorough squeezing of the cables into compact cylindrical form by powerful clamps. The wire wrapping will extend under the ends of the cast steel cable bands counterbored at each end to receive at least two complete turns of the wrapping wire which shall be secured to the bands in a suitable manner. The serving wire will be of No. 9 gage before galvanizing.

The ends of cable bands will then be made water tight by calking around the wrapping under the counterbore with lead and oakum or by pouring this joint with molten lead, thoroughly calked, as may be required by the engineer.

After the wrapping is applied and the cables, suspenders, hand rail ropes and fastenings are completed they shall receive one coat of red lead paint.

The anchorages for the foot-bridges and their fastenings at the tops of the main towers have been arranged

The strands when laid in the cables shall be supported by temporary saddles at points where the strands diverge from the solid cable in front of the anchor chains to their respective strand shoes, so that they will remain in their final position and to facilitate the operation of adjusting the side span deflections.

Two 1¼-in. diameter galvanized hand rail ropes shall be stretched above each of the main cables from anchorage to anchorage and anchored to the main cable saddles at front of the anchorages. The hand-rail ropes will be attached to the main cable bands at panel points by ⅜-in. diameter galvanized steel wire rope and will be set with a smaller deflection than the main cables to give a suitable initial stress in the strand fastenings and rigidity to the hand-rails themselves. Whenever it is necessary to change the direction of the hand-rail ropes it shall be done by supporting them on small columns or stanchions attached to the main cable bands.

The cable shield for filling the interstices between the wires of the cables shall be some form of neutral mineral oil or other material of composition and consistency approved by the engineer.

The cable shield shall be applied in a manner prescribed by the engineer to insure the most thorough and permanent filling of the interstices between the wires. As each individual strand is completed and temporarily

cure the highest degree of compression practicable in the cable wires and a thorough compacting of the serving wires.

Before the serving is applied all the cable shield shall be thoroughly cleaned from the surface of the cable (using benzine if necessary), and a thorough coat of red lead paste first applied in advance of the serving, in such a manner as to leave no spaces between the outer layer of cable wires or between these wires and the serving wires.

STIFFENING TRUSSES.—The four stiffening trusses of the bridge are riveted Warren trusses. Each truss is divided into three independent spans, two side spans and one main span. All three spans are supported by the cables. The side spans are anchored vertically to the abutments. These abutment anchors were shown in detail in our issue of Dec. 22, 1904. Connection between the truss end pin and the vertical anchor bar is made by means of a vertical rocker arm, details of which are shown by Fig. 14. At the tower ends, Fig. 15, the trusses are connected to brackets, Fig. 5, by means of rocker posts exactly similar to those used at the anchorages.

main trusses have also rocker post connections at the towers, and no expansion joints at the center; all the temperature movements of the trusses are provided for at the towers and anchorages.

The floor system and lateral bracing of the stiffening trusses are shown in diagram by Figs. 1 and 2. Wind strains are conveyed to the towers and anchorages by means of the vertical pin connections shown in Figs. 14 and 15. The other details of the stiffening trusses are sufficiently explained by the drawings.

MATERIALS.—The materials used for the substructure are described in the following excerpts from the specifications:

CARBON STEEL.—All structural steel, excepting that to be used in the architectural work, ladders, gratings and such similar minor details as the engineer may specifically exempt from the exclusive use of such steel, shall be made in an open hearth furnace lined with silica.

The ladle tests of steel as usually taken shall not contain more than the following proportions of the elements named: Phosphorus, .04%; sulphur, .04%; manganese, .60%; silicon, .10%. The ladle tests of the carbon rivet steel shall not contain more than .035% of phosphorus, and not more than .03% of sulphur. Rivet steel shall be used for all bolts and threaded rods.

NICKEL STEEL.—All nickel steel shall be made in an open hearth furnace lined with silica. The ladle test shall contain not less than 3.25% of pure nickel, and not more than the following proportions of the elements named: Phosphorus, .04%; sulphur, .04%; manganese, .60%; silicon, .10%. Nickel rivet steel shall contain not less than 3.25% of nickel and not more than .035% of phosphorus, nor more than .03% of sulphur.

Nickel steel for plates and shapes in the finished material must meet the following physical requirements: Ultimate strength, 85,000 to 95,000 lbs. per sq. in.; elastic limit, 55,000 lbs. per sq. in. minimum; elongation in 8 ins. (per cent.), $\frac{1,600,000}{\text{ultimate}}$ minimum; reduction of area, 40% minimum.

Specimens cut from the finished material shall show the following physical properties (see Table II.):

Nickel rivet steel shall have an ultimate strength of 70,000 to 80,000 lbs. per sq. in., an elastic limit of at least 45,000 lbs. per sq. in., and a percentage of elongation at least equal to $\frac{1,600,000}{\text{ultimate}}$ in 8 ins.

STEEL CASTINGS.—Steel for castings shall be made in an open-hearth furnace lined with silica. The ladle test of steel for castings shall not contain more than the following proportions of the elements named: Phosphorus, .05%; sulphur, .05%; manganese, .80%; silicon, .35%.

Test pieces taken from coupons on the annealed castings shall show an ultimate strength of not less than 65,000 lbs. per sq. in., an elastic limit of at least 35,000 lbs. per sq. in., and an elongation of not less than 20% in 2 ins. They shall bend without cracking 120° around a rod three times the thickness of the test piece.

TABLE I.—Showing Allowable Maximum Unit Stresses.

	For dead load, temperature and regular live load, or for dead load, temperature and wind.	For dead load, temperature and congested live load, or for dead load, regular live load, temperature and wind.
	Pounds per Square Inch.	
(a) For Wire:		
Main cables	60,000	73,000
Suspenders	30,000	.....
(b) For Nickel Steel:		
Tension in stiffening trusses	.....	40,000
Compression in stiffening trusses	.....	$*40{,}000-150\frac{l}{r}$
Shear on rivets in stiffening trusses; field	.....	20,000
Bearing on rivets in stiffening trusses; field	.....	35,000
(c) For Structural Steel in Towers:		
Tension	20,000	†25,000
Compression	$*22{,}000-90\frac{l}{r}$	$*27{,}000-100\frac{l}{r}$
Shear on shop rivets and bolts	13,000	16,000
Bearing on shop rivets and bolts	25,000	30,000
(d) For Structural Steel in Stiffening Trusses:		
Tension	20,000	24,000
Compression	$*20{,}000-90\frac{l}{r}$	$*24{,}000-100\frac{l}{r}$
Shear on shop rivets	13,000	.....
Bearing on shop rivets	25,000	.....
(e) For Structural Steel in Floor System of Roadway and Footways:		
Tension chords	15,000	.....
Shear on shop rivets, bolts and web-plate net section	10,000	.....
Bearing on shop rivets and bolts	20,000	.....
(f) For Structural Steel in Floor System for Railroad and Trolley Tracks:		
Tension chords	10,000	.....
Shear on shop rivets, bolts and web-plate net section	7,000	.....
Bearing on shop rivets and bolts	14,000	.....
(g) For Structural Steel in Anchorages:		
Tension in eye-bars	18,000	20,000
Bearing on diameter of pins	22,000	.....
Bending or outer fibre of pins	22,000	.....
Shear on pins	12,000	.....
(h) For High Carbon Steel:		
Tension in stiffening Trusses	.....	35,000
Compression in stiffening trusses	.....	$*35{,}000-135\frac{l}{r}$

* Where l = length and r = least radius of gyration both in inches. † Including secondary stresses.

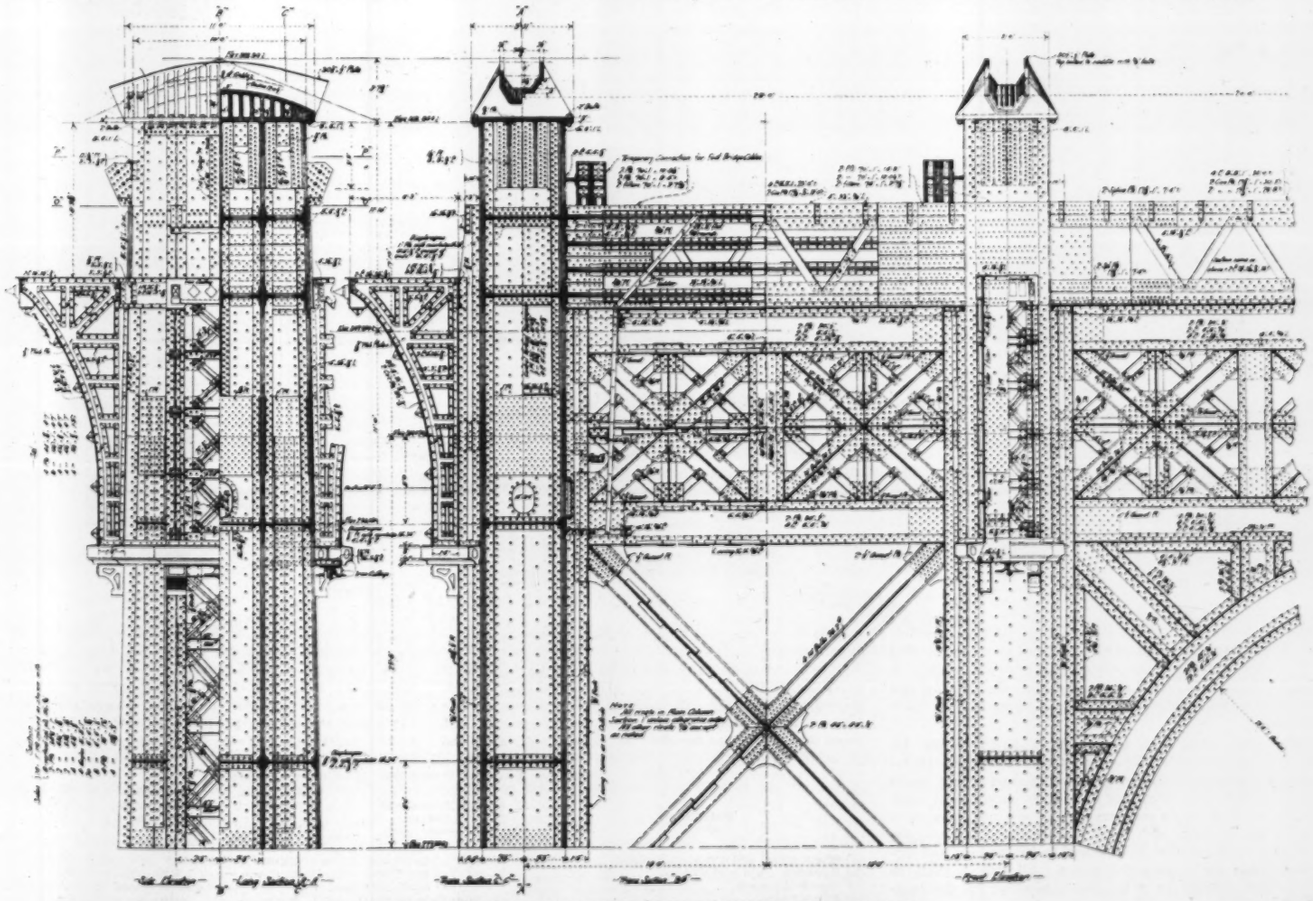


FIG. 8. TOP SECTION OF TOWERS, MANHATTAN BRIDGE.

MATERIAL FOR CABLES, SUSPENDERS AND HAND ROPES.—All steel for wire for the cables, suspenders and hand ropes shall be made in an open-hearth furnace, lined with silica. The wire for serving the cables shall be made of Norway iron of a quality approved by the engineer.

The ladle tests of the steel shall conform to the following chemical requirements: Carbon, not to exceed .85%; manganese, not to exceed .5%; silicon, not to exceed .20%; phosphorus, not to exceed .04%; sulphur, not to exceed .04%; copper, not to exceed, .02%.

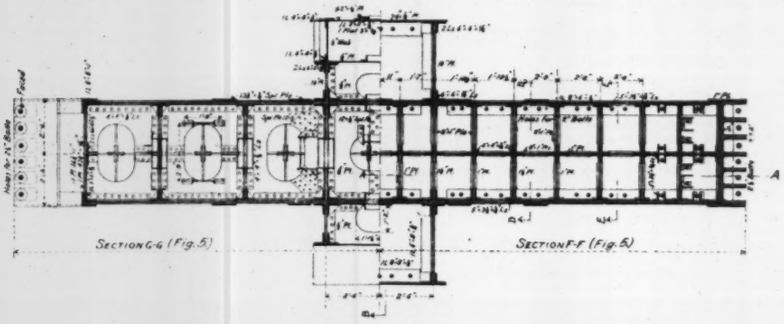


FIG. 9. HORIZONTAL SECTION OF TOWER LEG NEAR BASE.

The wire for cables, hand ropes and suspenders shall have an ultimate strength of not less than 215,000 lbs. per sq. in. before galvanizing, and an elongation of not less than 2% in 12 ins. of observed length, the stretch to be measured while the specimen is in the testing machine. The bright wire shall be capable of coiling cold around a rod 1½ times its own diameter without sign of fracture. The cable wire before galvanizing shall measure 192-1,000-in. in diameter as shown, and shall not vary in gage more than 3-1,000-in. It shall be drawn on large-sized blocks, and finished in single lengths of not less than 3,000 ft., and shall be drawn as straight as possible without any kinks or sharp bends. The serving wire shall be No. 9 gage before galvanizing. After galvanizing the steel wire shall have an ultimate strength of not less than 200,000 lbs. per sq. in. of gross section.

No machine straightening of wire will be allowed. The wire must not, from tendency to coil, cause trouble or delay during any of the operations from the splicing and winding on reels to the completion of stringing into cable strands.

The cable wires shall be spliced as shown on Fig. 13. The splice shall have a strength of at least 95% of the ultimate strength of the wire, so made that it will resist the tendency to open or part during the operation of cable making. The splice consists of a sleeve not more than ⅜-in. in diameter, with right and left-hand threads, the wires for shop splices having cold-rolled threads and mitered ends for locking the splice. All splices shall be carefully soldered in a manner prescribed by the engineer.

While reeling the wires on large reels after galvanizing and splicing, the wires shall be run through a bath of cable shield so that they will be thoroughly coated therewith.

The suspenders shall be 1¼ ins. in diameter and weigh not less than 5 1-10 lbs. per lin. ft. They shall be composed of six strands of 19 wires each, laid around an independent wire rope center consisting of 49 wires, left hand lay. The suspenders shall be, preferably, of long lay, but the lay must not be long enough to cause trouble in keeping the core in its true position during any of the operations before the suspenders are in their final position and loaded with the superstructure.

The wire for cables, cable serving, hand ropes and suspenders shall be galvanized and inspected as to the following requirements for galvanized wire: When galvanized, it shall gage not more than 5-1,000-in. larger than the bright wire. The galvanized wire shall have an elongation of 4% in 12 ins. of length, as observed under tension, and shall bend continuously around a mandrel four times the diameter of the wire without breaking or peeling off any of the zinc coating. The galvanizing shall consist of a coating of zinc 99.75% pure containing not more than .03% of iron. It shall be applied in the molten state in an even and uniform manner. The zinc coating shall be so applied that it will adhere firmly to the surface of the wire and form a continuous coating of uniform thickness.

All specimens of galvanized wire shall be capable of withstanding the following test: The sample shall be immersed in a standard solution of copper sulphate for one minute, immediately washed in water thoroughly and wiped dry. This process shall be repeated. If, after the fourth immersion there should be a copper-colored de-posit on the sample or the zinc should have been re-moved, the sample shall be rejected. The standard so-lution of copper sulphate shall consist of a solution of com-mercial copper sulphate crystals in water. This solu-shall have a specific gravity of 1.185 at 70° F. While sample is being tested, the temperature of the standard so-lution shall at no time be less than 60° F., nor m-than 65° F. While galvanizing the cable wire shall coiled on blocks not less than 4 ft. in diameter.

The suspender ropes shall be cut to accurate leng-with careful corrections for stretch under temporar-and permanent load, and the two ends of each suspen-shall be socketed with the cast steel screw threaded so-ets shown on the plans. Full size tests of suspenders a-sockets shall be made to determine their strength a-also the modulus of stretch of ropes for use in gett-true length of suspenders. There will be four suspen-ers at each panel point of each cable, or two loops o-each main cable band. Each pair of suspenders will-drawn together at a point about four feet below the-tre of the cable, as shown on the plans, and the ut-care shall be taken in adjusting them to insure a uni-distribution of load on the suspenders, in a manner p-scribed by the engineer.

The main cable bands must have the grooves in wh-the 1¾-in. suspender ropes are to rest chipped and fi-sufficiently to remove all irregularities and to leave th-smooth and true, so as to afford satisfactory bearings-the suspenders. The inner surfaces of all cable ban-shall be accurately bored to true cylindrical form, wi-the ends counter bored as shown on the plans. Strips-steel of triangular section shall be provided at the joint-made by the two halves of the cable bands for confining-the cable wires. These strips of steel and the surface-of bands against which they bear shall be accurately m-chined. The cable bands shall be machined along the abut-ting flanges, and wherever else required to make a satis-factory finish. Where the cables enter the saddles at th-tops of the towers, the wires shall be left practically, fre-from the saddles to the first cable bands, about 11 ft-from the center of the tower on either side of the sad-dles. In order to protect the cables from the weather at-these points, suitable copper covers with flexible joints-will extend from the ends of saddles to the bands before-mentioned.

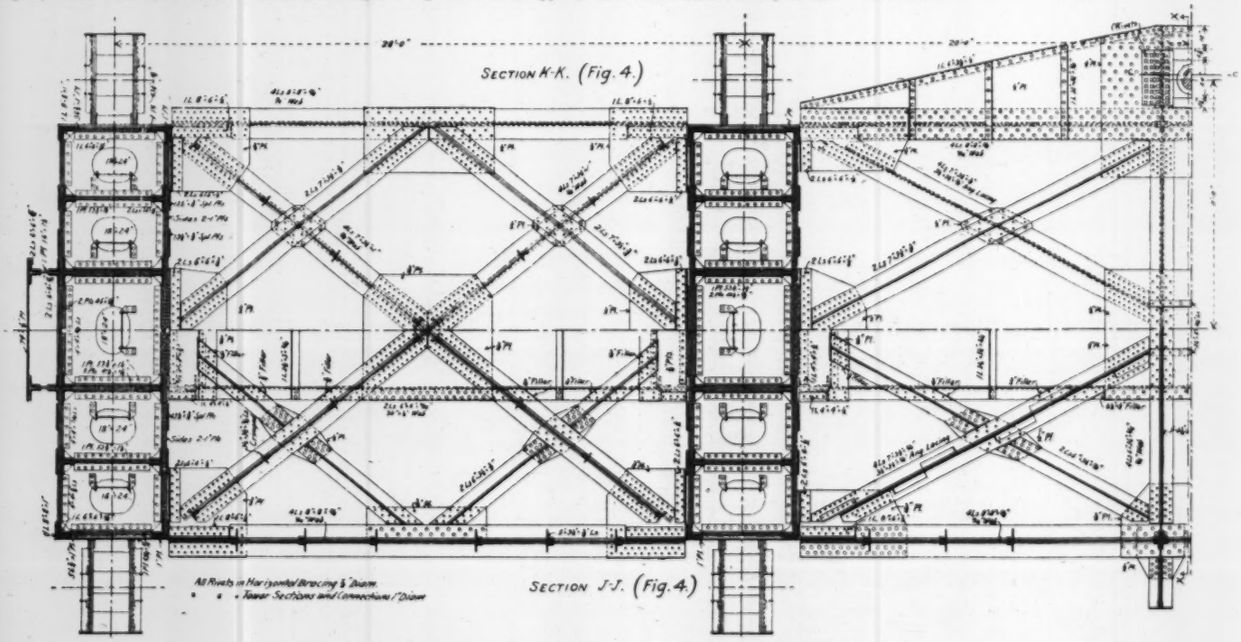


FIG. 10. HORIZONTAL BRACING OF TOWERS AT ROADWAY LEVEL.

LOADS.—The bridge is proportioned to carry, in addition to its own weight and that of the floor, a live load either uniform or concentrated, or both as specified below, placed so as to give the greatest stress in each part of the structure: (1) For the cables, trusses and towers: (A) A load of 8,000 lbs. per lin. ft. of bridge as "regular," or (B) 16,000 lbs. per lin. ft. of bridge as "congested"

TABLE II.—Required Physical Properties of Finished Material.

Material.	Ult. strength lbs. per square inch.	Minimum elastic limit lbs. per square inch.	Minimum elongation per cent. in 8 inches.	Minimum reduction per cent. of area.
(a) Shapes and universal mill plates	60,000 to 68,000	33,000	1,500,000 / ultimate	44 per cent.
(b) Eyebars, pins and rollers	64,000 to 72,000	35,000		40 "
(c) Sheared plates	60,000 to 68,000	33,000		44 "
(d) Rivet rods	50,000 to 58,000	30,000		50 "
e) High carbon steel for trusses	85,000 to 95,000	45,000		35 "

TABLE III.—Summary of Approximate Weights of Materials.

	Anchorages. Lbs.	Towers. Lbs.	Cables. Lbs.	Main span. Lbs.	Side spans. Lbs.	Totals. Lbs.
Nickel steel	.....	.....	.....	7,349,600	8,897,800	16,247,400
Structural steel	1,335,600	21,333,800	30,200	10,602,600	10,447,200	43,749,400
Wire	.....	.....	12,176,200	.....	.....	12,176,200
Spun cables, etc	.....	.....	1,153,600	.....	.....	1,153,600
Eyebars	3,731,900	.....	.....	.....	.....	3,731,900
Castings, steel	1,500	3,385,200	1,744,600	13,700	28,200	5,173,200
Castings, iron	18,500	189,100	54,500	7,600	24,600	294,300
Pins, bolts, nuts, etc	307,500	119,100	383,000	10,000	22,600	842,200
Totals of steel	5,395,000	25,027,200	15,542, 00	17,983,500	19,420,400	83,368,200
Concrete (cu. yds.)	.....	930	.....	.....	.....	930
Bronze	400	.....	12,000	2,100	4,200	18,700
Zinc	.....	.....	25,200	.....	.....	25,200
Lead	.....	20,600	7,400	.....	.....	28,000

traffic. (2) For the hangers, floor beams and floor systems: (C) On each elevated railroad track a load of 52 tons on 4 axles, 6 ft. plus 10 ft. plus 6 ft. apart (the motor ends of 2 motor cars of the Interborough Rapid Transit Co.). (D) On each street car track either a load of 26 tons on 2 axles 10 ft. apart or a load of 1,800 lbs. per lin. ft. of track. (E) On any part of the roadway a load of 24 tons on 2 axles 10 ft. apart and 5 ft. gage (assumed to occupy a width of 12 ft. and a length of 30 ft.), and upon the remaining portion of the floor a load of 100 lbs. per sq. ft. (F) On the footwalks a load of 100 lbs. per sq. ft.

The wind pressure is assumed as a moving load acting in either direction horizontally with 2,000 lbs. per lin. ft., but due allowance is made by taking the lateral deflection into account.

PROPORTIONING OF PARTS.—All steel work shall be so proportioned that the maximum stresses shall not cause greater unit stresses than are shown in Table I:

In field driven carbon steel rivets, 15% shall be added to the number of rivets required by the foregoing permissible stresses.

Table III. shows the approximate weights of materials for the different parts of the superstructure.

ENGINEERS.—The Manhattan Bridge is being built by the Department of Bridges of the city of New York, Geo. H. Best, Commissioner; O. F. Nichols, M. Am. Soc. C. E., Chief Engineer, and R. S. Buck, M. Am. Soc. C. E., Consulting Engineer.

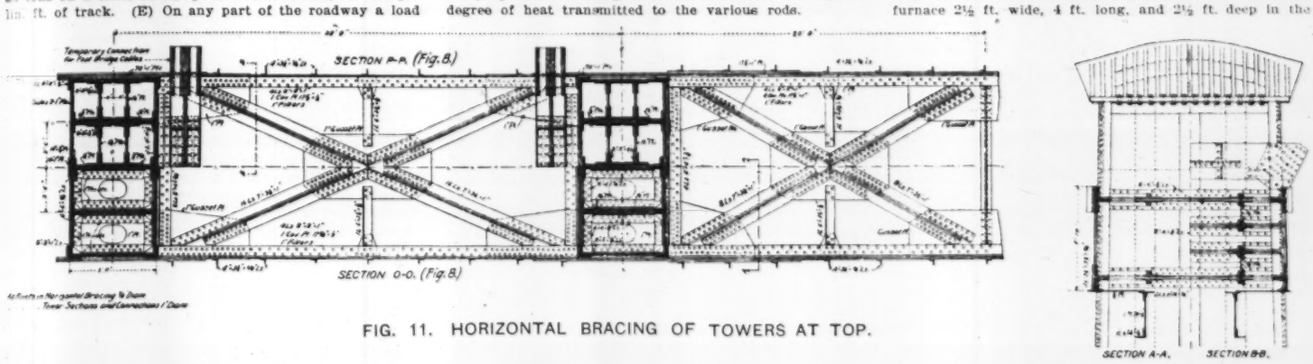


FIG. 11. HORIZONTAL BRACING OF TOWERS AT TOP.

TESTS TO DETERMINE THE FIRE RESISTANCE AND HEAT CONDUCTIVITY OF CONCRETE.*

The following tests were based on the theory that concrete construction depends for its fire resistance chiefly, if not wholly, not on the style of its reinforcement, but on two essential qualities of the concrete itself—viz., its ability to withstand cracking or disintegration which should reduce its own strength or expose the steel it was designed to protect and its heat insulating value as a steel protection even when not broken or disintegrated. The samples for test were in the form of beams 8 × 11¼ ins. × 6 ft., each containing three plain round steel rods 6 ft. 6 ins. long, and projecting about 3 ins. at each end and located 1, 2 and 3 ins., respectively, from the bottom of the beam. Holes were left from about the middle of each rod to the top surface of the beam for the purpose of inserting thermometers for measuring the degree of heat transmitted to the various rods.

The composition of the beams, materials measured by volume, was as follows:

	Portland Cement.	Sand.	Coarse Gravel (Screened).
Sample No. 1	1	2	3
" No. 2	1	2½	5
" No. 3	1	3½	7
	Portland Cement.	**Sand.**	**Lime Stone Not Larger than 1¼".**
Sample No. 4	1	2	3
" No. 5	1	2½	5
" No. 6	1	3½	7
	Portland Cement.	**Sand.**	**Screened Red Granite Not Larger than 1¼".**
Sample No. 7	1	2	3
" No. 8	1	2½	5
" No. 9	1	3½	7
	Portland Cement.	**Sand.**	**Cinders (Not Specially Selected, but Same Quality as Are Commonly Used in Practice).**
Sample No. 10	1	2	5
" No. 11	1	2	6

The aggregates contained the following percentages of voids: Granite, 40%; gravel, 36%; limestone, 42%—which indicates that the samples containing the medium and larger quantities of cement were nearest the ideal composition; while the leaner ones were not quite strong enough.

These aggregates were selected as representing such variety of materials commonly used as was available in Chicago. Sand was of considerable range in size and fairly sharp. The cement was the "Wolverine" brand, made by the Michigan Portland Cement Co., of Detroit, reputed to be a high grade cement. Samples were taken from each bag and mixed together, and tested by Prof. R. Burnham, of Armour Institute, who reports the following results:

Amount passing No. 100 sieve, 94%. Amount passing No. 200 sieve, 80%. Specific gravity, 3.10%. Tensile strength after 24 hours in moist air, 206.3 lbs. per sq. in. Tensile strength after 24 hours in moist air and six days in water, 480.7 lbs. per sq. in. The tensile tests were made on neat cement and the figure given is the average of ten tests.

All the materials were purchased in the open market and not intended to represent any special system of construction.

The samples were all made on April 1 by experienced workmen, under the direction of R. & S. Sollitt, of Chicago, a prominent firm engaged in that sort of work as contractors. In mixing, the sand and cement were laid down first and turned over with shovels four times, then the stone and water added and the whole shoveled over four or five times more, enough water being added to make a medium wet mixture. The beams were taken out of the molds on May 2 and were left, both before and after removal from the forms in the shaded corner of an open yard, where they were occasionally wet by rain.

At the age of 45 to 48 days the beams were tested two at a time while laid so as to form the roof of a low brick furnace 2½ ft. wide, 4 ft. long, and 2½ ft. deep in the clear. Ventilating holes 3 × 8 ins. were left at each side of both ends of the furnace. The furnace was heated by two 3-in. Bunsen burners, using natural gas, over which was laid an open brick lattice work to distribute the heat evenly through the chamber.

A Le Chatelier pyrometer was inserted through the top of the furnace so that its point was between the two samples and about an inch below their lower surface, and three standard mercury thermometers reading up to 650° F. were inserted in each beam with their bulbs resting on the steel rods. No attempt was made to load the beams.

Each sample was kept in this furnace three hours, while the temperature as indicated by the pyrometer gradually rose to about 1,900 to 2,000° F. They were then taken out and allowed to cool in the open air without the application of water. While there is some difference in the speed with which temperature rose, there is no indication that the difference in the materials composing the concrete was an important factor in the insulating quality of the product, except in the case of the two cinder samples, in both of which the rise in temperature of the rods was quite noticeably slower than in any other sample. There also is a clear indication that the richer mixtures of all materials were slower conductors.

The time required to heat up the rods in all samples which had only 1 in. of concrete covering, as compared with those covered 2 and 3 ins. deep, is the prominent feature of the temperature records and indicates clearly that reinforcing steel members covered to that depth only reached a temperature of 770° F., where their strength is impaired to the extent of 25% very early, well within 1½ hours, or averaging 50 minutes for the 11 samples. Those with 2-in. covering attained the same temperature in an average of 2 hours and 20 minutes, and those protected by 3 ins. of material, in 2½ hours, on an average.

In none of the samples was there any sign of breaking or chipping off of the concrete during the fire, but after being removed it was found that the material had lost

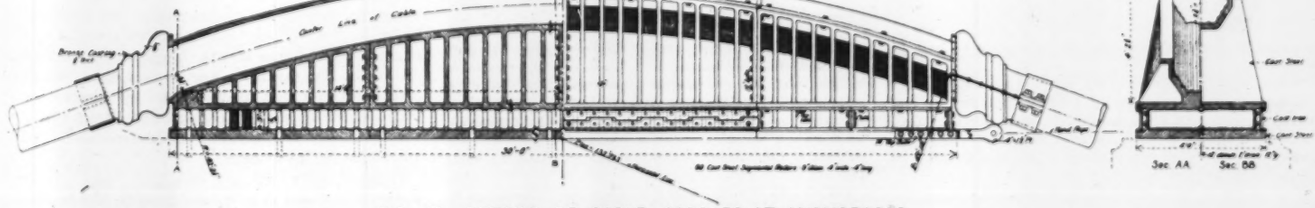


FIG. 12. DETAILS OF CABLE SADDLES AT ANCHORAGES.

*Abstract of special committee report presented at the ninth annual meeting of the National Fire Protection Association, May 23-25, 1905.

practically all its strength to a depth of about 4 ins. from the sides and bottom and that it had softened perceptibly clear to the top. The cement and most of the stone, including both limestone, gravel and granite, seem to have been calcined quite thoroughly at the surface and in a diminishing degree up to about the 4-in. depth. There is no very wide difference in this respect between the various samples, though the beams having the greatest proportion of cement seem to be somewhat more solid than the others.

In all cases, a little water and steam appeared during the test at a few cracks running across the top of the beams, this being most noticeable in the richest mixtures and appearing chiefly during the time the thermometers indicated 212° F., as they did for periods of 20 to 40 minutes.

The accompanying table also shows the deflection of each beam as varying from 1-16 to ¼ in., and the expansion of the beams and the individual rods as from ¼ to 11-16 in.

Your committee realizes that these tests are very incomplete and far from being entirely satisfactory; but they are submitted for consideration with the hope that they will give some indication of the proper direction for future investigaions which may result ultimately in a standard for concrete construction.

Sample No.	Age, Days.	Maximum Deflection.	—Longitudinal Expansion.— Lower Rod	Middle Rod.	Upper Rod.	Beam.
1....	45	⅛	⅛	⅛	⅛	⅛
2....	45	⅛	⅛	⅛	⅛	⅛
3....	46	⅛	⅛	⅛	¼	⅛
4....	47	⅛	⅛	⅛	⅛	⅛
5....	47	⅛	⅛	⅛	⅛	⅛
6....	46	⅛	⅛	⅛	⅛	⅛
7....	47	⅛	⅛	⅛	⅛	⅛
8....	47	⅛	⅛	⅛	⅛	⅛
9....	48	⅛	⅛	⅛	⅛	⅛
10....	48	⅛	⅛	⅛	⅛	⅛
11....	48	⅛	⅛	⅛	⅛	⅛

The tests were planned to give a severe but not excessive trial as to duration and temperature of furnace, but we feel that they were distinctly favorable to the material in that no load was applied and that they were not wet by hose streams while hot. With the limited time and facilities at hand it was not feasible to arrange these conditions, but it is quite probable that with added strains, imposed by loading or wetting, less favorable results might have been obtained.

At present your committee would not attempt to submit a standard for concrete construction, but would suggest a few general principles on which such work should be planned.

First—The work should invariably be designed and its entire erection supervised personally by engineers of skill and experience in this particular line.

Second—Concrete for fireproof construction should be composed of high grade tested Portland cement, clean sand and broken stone, gravel, slag or cinders, so proportioned that the cement will completely fill the voids in the sand and the mortar thus formed will a little more than fill the voids in the aggregate.

Third—The materials should be well mixed by machine with enough water to make the mass distinctly a "wet mixture," and should be tamped down so that no voids are left.

Fourth—All steel members of whatever style should be imbedded at least 2 ins. in the concrete, and in the case of important load-carrying members, 3 ins.

Fifth—No cement work of any kind should be laid in cold weather without being safely guarded against freezing. This will be disputed, but is correct beyond reasonable doubt.

Referring to the second of these recommendations, the kinds of stone permissible is a matter of some question; while our tests did not demonstrate it, the fact is that limestone and granite, especially in cases where the individual stones are of large size, by breaking and bursting under fire have in other tests broken the concrete mass and these stones are therefore not generally considered reliable for good concrete.

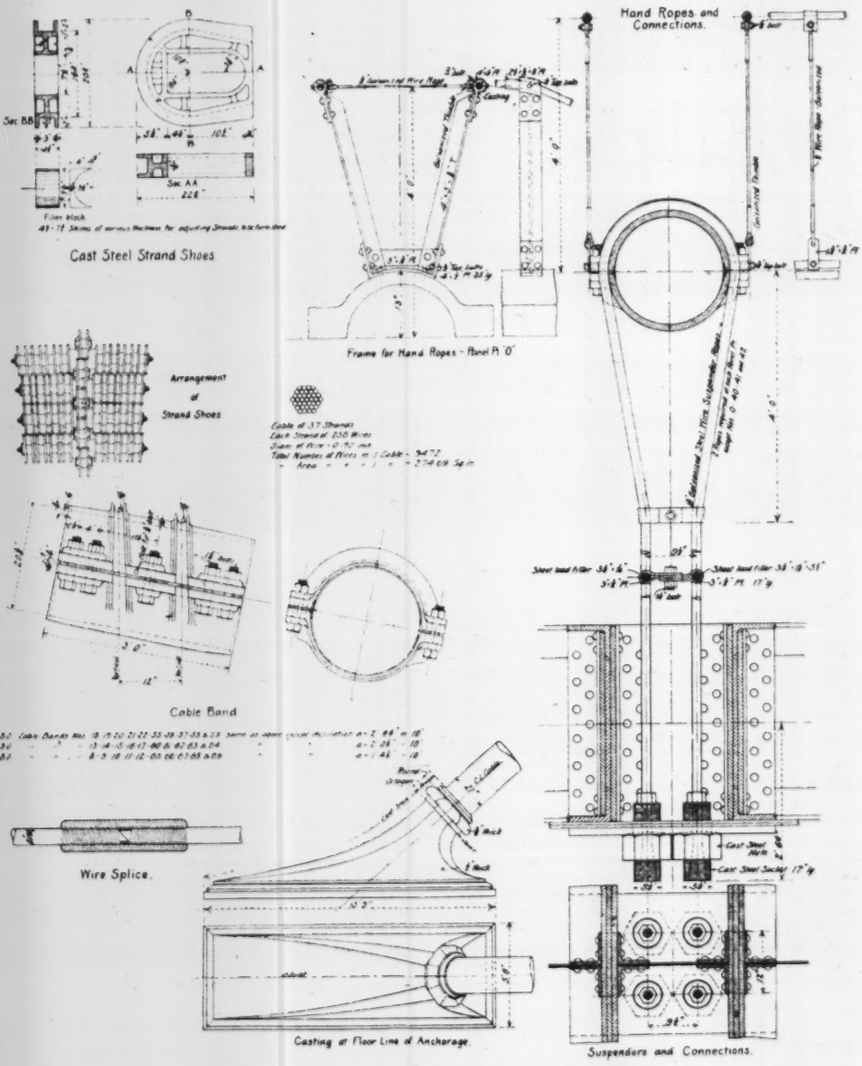

Cast Steel Strand Shoes
Arrangement of Strand Shoes
Cable Band
Wire Splice.
Hand Ropes and Connections.
Frame for Hand Ropes - Panel Pt. 0
Casting at Floor Line of Anchorage.
Suspenders and Connections.

FIG. 13. DETAILS OF CABLES AND SUSPENDERS.

Another increasingly important branch of this subject is concrete blocks or artificial stone, which are rapidly coming into common use for wall construction, particularly for small buildings, such as dwellings and barns. This material is claimed to be the equal of brick in all respects with the advantage of being easily available at any location, and under some conditions cheaper than brick. It also has a somewhat doubtful advantage in resembling natural stone to some extent. It is composed of Portland cement and sand molded into hollow blocks of varying sizes and shapes, usually in the neighborhood of 8 × 16 to 12 × 30 ins. and 8 to 10 ins. in thickness. Some blocks contain single and some double air spaces equaling 30% to 50% of the entire block, which makes a shell of 2 to 3 ins. thick on each vertical side and leaves the top and bottom open.

There is no patent on these blocks; they are being made by a great many people all over the country, and each maker of course is at liberty to use any kind or proportion of materials he chooses, being influenced to good or bad product by commercial exigencies and his own ideas of what constitutes a good block. Most of the blocks are being made on machines built for the purpose by numerous manufacturers who are interested in seeing the art developed and the market for their machines extended. These machine builders are generally advising the block makers to use only standard Portland cement and to mix it with clean sand in the proportion of not more than four of sand to one cement. The chief reason for recommending this proportion is that a block with a smaller percentage of cement is too porous and absorbs moisture so easily as to make the wall damp. For the purpose of preventing this absorption of moisture, some makers use a richer mixture with extra fine sand (about three to one) for a thin facing on the outside of the block and a leaner mixture for the main bulk.

We have not yet been able to make any tests of fire resistance of these blocks, but would venture the opinion that when made in the proportion of one to four or five, they will not be found to differ widely from other forms of concrete as to heat conductivity or tendency to disintegration, but the fact that they are hollow and that the side of the shell next the fire would heat up more rapidly than the other sides, would allow an unequal expansion which might result in the hottest side breaking away from the others, in exactly the same manner as hollow tile breaks. Whether this theory is correct or not, and if so, at what temperatures and at what time in the fire serious breaking would occur, should be the subject of investigation. Another important question is, what effect fire would have on the mortar joints between these blocks. It is well known that new concrete does not bond well with old, and whether or not common cement mortar makes a sufficiently strong bond between two pieces of concrete which have been allowed to set for some weeks, is a matter of doubt.

It may reasonably be expected that within a few years the commercial development of the cement block industry will result in an increasing uniformity of practice, but it would seem that while this development is going on, investigation by this or similar bodies, tending to demonstrate the methods and materials necessary to produce a block of high fire resistance, would be in order.

TASTES AND ODORS IN RIVER WATER SUPPLIES.

The following information regarding tastes and odors in water taken directly from rivers, in contrast with those which develop during artificial storage, was collected in January, 1905, by Mr. Dow R. Gwinn, President of the Terre Haute Water-Works Co., of Terre Haute, Ind. We are indebted to Mr. Gwinn for a copy of the notes which he collected and compiled. We have added in its proper alphabetical place an account of the experience at Terre Haute, prepared by us from a letter by Mr. Gwinn. For convenience, we have inserted the name of the river in question near the beginning of each paragraph. Brief editorial comment on this general subject may be found elsewhere in this issue.

ALBANY, N. Y.—Wallace Greenalch, Supt. (Hudson River): Have been more or less troubled with taste suggestive of decayed wood. Taste usually appears in November when the temperature of the water is suddenly lowered, but not necessarily with the appearance of ice; taste appears in November and lasts four or five weeks, when it disappears entirely.

CEDAR RAPIDS, IA.—Chas. J. Fox, Supt. (Cedar River): Have bad taste every year after river freezes over. Our chemist thinks the bad taste is caused by vegetation in the water, which is not oxidized owing to the river being covered with ice.

...ES, N. Y.—W. T. Kniffin, Supt. (Mohawk River): We ... not have any trouble with bad taste, presumably on ... nt of the water, when it leaves the river, flowing ... idly through a canal free from ice for one-half mi... before it is pumped into the reservoirs.

...VILLE, ILL.—G. B. Sidelinger, Supt. (North Fork Vermilion River): I have known of ponds and lakes where a ... supply was being taken to give trouble, but when the ... company commenced to cut the ice, in a day or so ... e odor completely disappeared. Our river (or brook) never has any odor when frozen over, because there are many riffles that never freeze, which aerates the water.

...VENPORT, IA.—T. N. Hooper, Vice-Pres. (Mississippi River): We have no trouble with odor or taste and we never do have during the winter months. We attribute the condition largely to air holes that are in the ice. Being located on the Rock Island Rapids, the current in the river is so strong that there are bound to be air holes. Our reason for believing that air holes prevent odor and taste is that a number of years ago they had trouble on the Hackensack River and Professor Leeds of Stevens Institute of Technology was called to investigate the trouble. He found the drainage area all right, but the river was frozen over 80 miles without an air hole. He bored a hole in the ice and the gas rushed out with great velocity, and, touching a light to it, it burned like (illuminating?—Ed.) gas. He then had a large hole cut above and around the intake pipe and the taste disappeared.

...ELMIRA, N. Y.—J. M. Diven, Secy. (Chemung River): ... have had trouble with bad taste in the summer. Have had no experience in treating water during winter.

...ENERAL.—W. S. Kuhn, Gen. Mgr., Amer. Water-...ks & Guarantee Co., Pittsburg, Pa., (Various): We ... many times been troubled with the odors you men-... and have overcome them, as you suggest, by aeration. We have, however, had no success with forcing air into the water, but get good results by elevating the water and letting it fall in cascades that thoroughly break it up before it comes to rest. Aeration for this purpose has been successfully used by us at Shreveport, La.; Meridian, Miss.; Birmingham, Ala.; Little Rock, Ark.; Elizabeth and New Castle, Pa.; and is now being installed at East St. Louis, Ill.

INDIANAPOLIS, IND.—F. A. W. Davis, Pres. (White River): We have had bad taste and odor, but attribute it to paper mills emptying refuse into the White River.

KANKAKEE, ILL.—C. Collins, Agt. (Kankakee River): In February, 1904, we had trouble with disagreeable odor for about two weeks, but the taste was not affected. Trouble only lasted two weeks.

LAWRENCE, MASS.—M. F. Collins, Supt. (Merrimac River): We have had trouble more or less for years. In

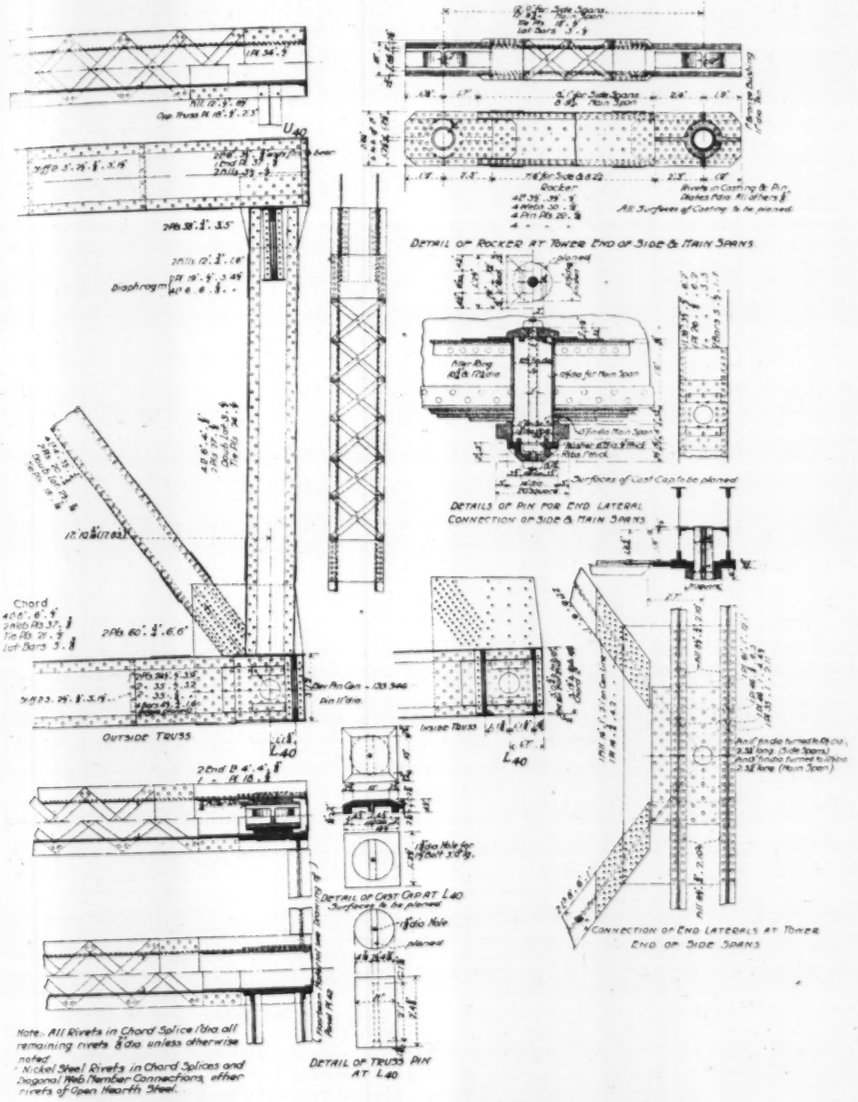

DETAIL OF ROCKER AT TOWER END OF SIDE & MAIN SPANS
DETAILS OF PIN FOR END LATERAL CONNECTION OF SIDE & MAIN SPANS
OUTSIDE TRUSS
INSIDE TRUSS
DETAIL OF CAST CAP AT L40
CONNECTION OF END LATERALS AT TOWER END OF SIDE SPANS
DETAIL OF TRUSS PIN AT L40
Note.—All Rivets in Chord Splice (also all remaining rivets & 6in. unless otherwise noted.
Nickel Steel Rivets in Chord Splices and Diagonal Web Member Connections, other rivets of Open Hearth Steel.

FIG. 14. DETAILS OF TOWER ENDS OF SIDE SPAN TRUSSES.

falling into the reservoir from 2 to 6 ft. The swampy smell disappeared since this device was adopted.

At the present time we are using driven well water which does not freeze in our reservoir, so we have no trouble of this kind. The aeration of the river water by means of wooden apron described did put an end to the odor at the time and for the years after until 1896, when we discontinued the use of river water.

LOUISVILLE, KY.—Chas. Hermany, Supt. (Ohio River): This odor is faintly discernible at the present time in the Ohio River water, and has been for several months, during which time the water in the river has been at its lowest stage, except for the past three weeks. It has been so slight as not to have caused any complaint, nor even comment; have considered it to be due to a decoction from various partly decayed vegetable substances deposited in bog and pond waters which, during the late summer and fall—the dry season—had no exchange of stored water and consequently became saturated with say, tannic acid, for want of a better name, or something analogous, extracted from partly decayed vegetation, and with it acquiring an odor that becomes inseparable therefrom as long as it remains water. When the fall rains commence, this infused water is displaced and finally finds it way into the rivers, where its attic quality asserts itself.

MUSCATINE, IA.—Wm. Molis, Supt. (Mississippi River): We have had trouble with the Mississippi River water, but some years ago; not any lately. I cut a big air hole, about 20 ft. square, over the intake or crib, and it seemed to help things wonderfully.

POUGHKEEPSIE, N. Y.—C. E. Fowler, Supt. (Hudson River): Occasionally have a little of the woody taste, but not sufficient to cause complaint. Taste was quite pronounced the latter part of December and first of January, but has almost entirely disappeared, although river is still covered with ice.

PERU, IND.—Jas. P. Morrisey, Supt. (Wabash River): Have had complaint about bad taste since the Wabash River became frozen over. We only use about one-eighth of the supply from the river; the balance is from wells. Have never done anything to overcome the taste.

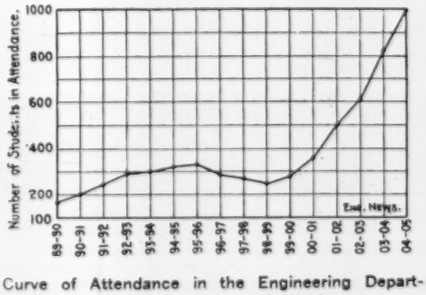
TERRE HAUTE, IND.—Dow R. Gwinn, Pres. (Wabash River): Although the water is aerated to a considerable extent before being delivered into the settling basin (4 to 6 hours sedimentation), and is treated by mechanical filtration and then pumped direct to the consumers, yet trouble has been experienced with bad tastes. Moreover, a sample of water taken from the river 15 miles above our intake has the same disagreeable taste as is present in our river water here.

VINCENNES, IND.—L. J. Weisenberger, Supt. (Wabash River): We have had a taste in the Wabash River water similar to decayed wood.

WATERLOO, IA.—J. P. Berry, Supt. (Cedar River): Have the bad taste in water, but do not think it is due to the presence of ice in the stream, but is due to the fact that during the winter the water in bayous and in many other places where it comes in contact with leaves and weeds of all kinds in a state of decomposition contaminates it, and whenever we get a thaw or a rain this water, which is badly polluted, is washed into the stream, and if there is no ice on the river the taste in the water would be the same.

THE GROWTH OF THE ENGINEERING DEPARTMENT OF THE UNIVERSITY OF MICHIGAN.

In view of the statistics given in our editorial of June 1 showing the great increase in the number of students in engineering colleges, the accompanying diagram, redrawn from the "Michigan Technic," will be of interest. The decline in the



Curve of Attendance in the Engineering Department of the University of Michigan.

few years following 1895-6 is explained by the industrial depression of those years. Those who claim that the development of an engineering college is hampered by its being part of a great university, will find food for reflection in this diagram.

THE IRREGULAR FLOW OF RIVERS IN HUMID PRAIRIE STATES.

By F. W. Hanna.*

Every one who has lived in the humid prairie portions of the United States holds the view that the minimum and maximum run-off of their streams are both greatly accentuated. The fact that small creeks once constant sources of water supply, small rivers once lined with mills, and large rivers once considered navigable, have all lost their constant efficiency in these respects, is a common and universal remark. This widely held opinion cannot be due entirely to the magnifying views of youth. Where there is so much decided belief there is likely to be some truth. Flooded cities, records of mill owners, and long existing records of gage heights of rivers all substantiate the correctness of this opinion.

A great deal of scientific research and a considerable more scientific discussion have been devoted to the determining of the relation of forests to stream run-off. In this research it has been conclusively proved that forests serve to regulate the flow of streams. However, out of this principle of forest conservation of stream flow has arisen an erroneous popular idea that deforestation is the primary cause of floods and drouths in all streams. That deforestation is partially and sometimes wholly responsible for these conditions where forests once existed is without doubt, but that it is not responsible where forests never existed is certainly much more evident. It is a well known fact that the rivers of Iowa, Illinois, Southern Minnesota, Southern Wisconsin, and Northern Missouri have all suffered great changes in regularity of flow since the conversion of their vast prairies into cultivated and pastured fields has taken place. In the transformation of these prairie lands into cultivated fields, lands as are not under cultivation are now pastured by stock. The grass is grazed so closely as to deprive it of its obstructiveness to surface flow of water. Moreover, the constant tramping of the pasturing animals over the ground has formed a non-porous crust over it, which has greatly reduced its permeability. As to the comparative surface run-off from cultivated fields and wild grass uplands little can be definitely stated. Differences in vegetation-consumption, evaporation and percolation make the problem very complicated. From a number of years of observation the writer is of the opinion that the annual difference of storm run-off from wild and cultivated upland is not sufficient to have any very appreciable effect in causing irregularity of stream flow.

Originally about one-twentieth of the entire area of the prairies was probably wet marsh lands. These wet lands consisted of the ordinary swamp and slough. The swamp as locally termed was a low portion of ground that had very imperfect drainage, the outflow being entirely under there has been very little deforestation. While there were a few native trees scattered here and there, yet the acreage of this timber was so small as to have had little effect on the run-off of the streams whose drainage areas they covered. The cause, therefore, must arise from some other source.

It is the opinion of the writer that the changes in the regularity of flow of the rivers under discussion have been caused mainly by pasturage drainage, and cultivation. All of the vast prairies of this region were at one time covered by thick growths of grass, which on the uplands usually attain the height of 1 to 2 ft., and which on the low lands reached the height of 5 ft. or more. The uneven surface of the prairies caused by tufts of roots, coupled with this thick growth of grass, made surface run-off slow, and, thereby, greatly decreased it. Such of the original grass ground except in a few cases after extreme p cipitation. The characteristic slough of this gion filled the upper portions of the creek valle They varied from five to forty or more rods width and from one-half to two or more miles length. In the upper part there was no def channel, in the middle portion an indefinite of water way existed, while in the lower part slough began to assume something of a defi channel that emerged from it in the form of creek. This entire area was covered with a he growth of flags, reeds and extremely luxuri coarse grass. The vegetation grew several in height and was very dense. The soil was tremely porous and rich, being composed masses of roots and decayed grasses. Layers this material were always several feet in de For a number of days after a heavy rain the w stood several inches deep in this growth of v

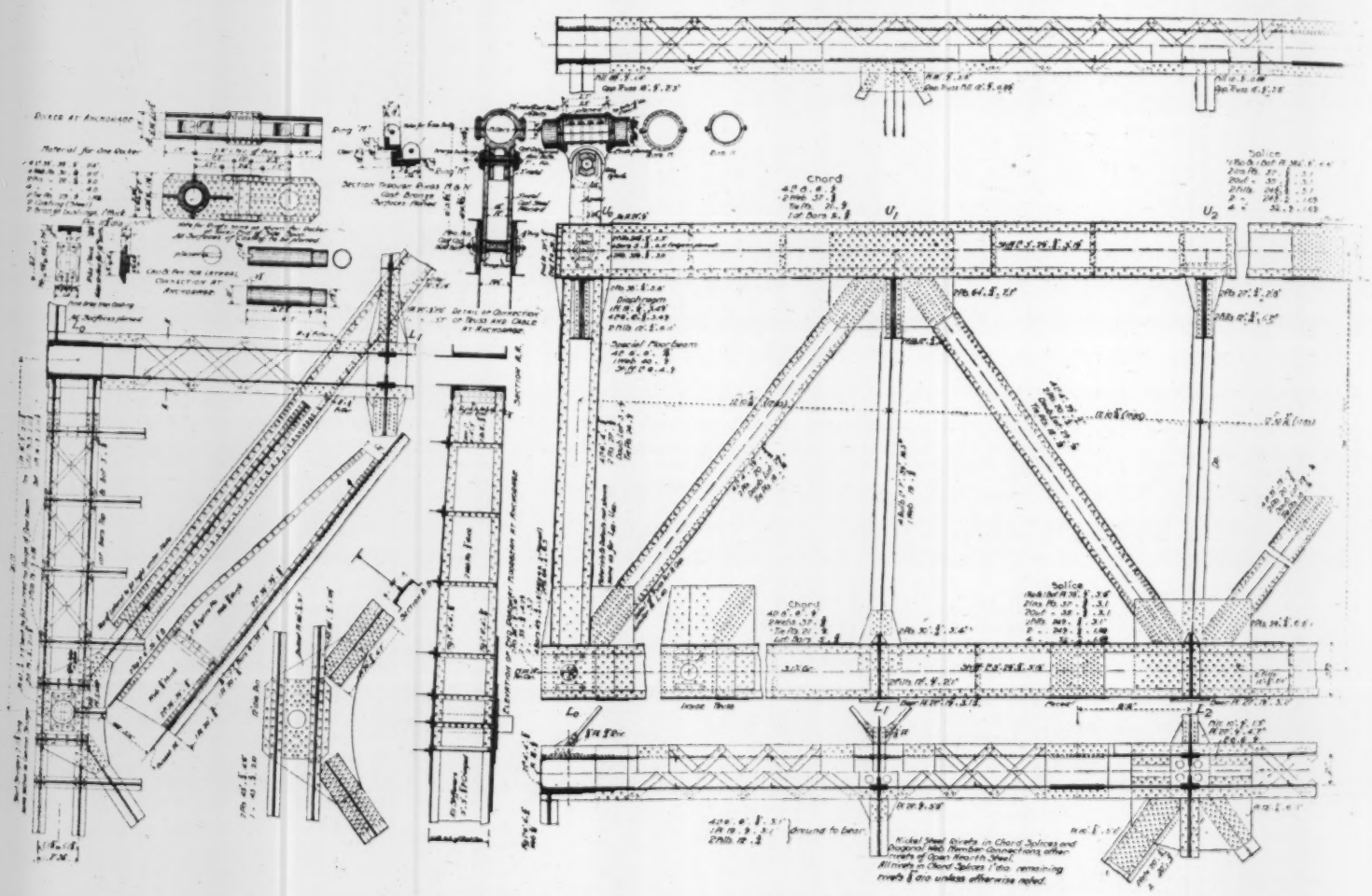


FIG. 15. DETAILS OF ANCHORAGE ENDS OF SIDE SPAN TRUSSES.

tation, and the porous soil became completely saturated with it. In fact, throughout the entire year, with the exception of unusually dry ones, these sloughs were practicaly impassable. These swamps and sloughs served as regulators of the stream flow.

The majority of these natural reservoirs have been drained by small ditches that have grown into comparatively enormous proportions both laterally and vertically. These ditches have cut down through the peaty soil, thus reducing the ground water level, and the once impassable slough is now either cultivated or pastured. If the area of these sloughs approximated one-twentieth of the tributary area of a river having a drainage area of 1,000 square miles there would be in this basin 50 square miles of slough reservoirs. Now, if it is assumed that the water after a heavy rain stood 0.1 ft. deep over this area above the ground proper, and that it took five days to escape from the slough, there would be 323 sec. ft. added to the flow of the river during this period.

Let it be still further assumed that the depth of

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saturation capable of escaping in the next 30 days, there being no further rainfall, is 3 ft., and that the delivering porosity is 20% of the volume of the saturated soil; there would then be 19,200 acre-feet of water on the 50 sq. miles of wet land

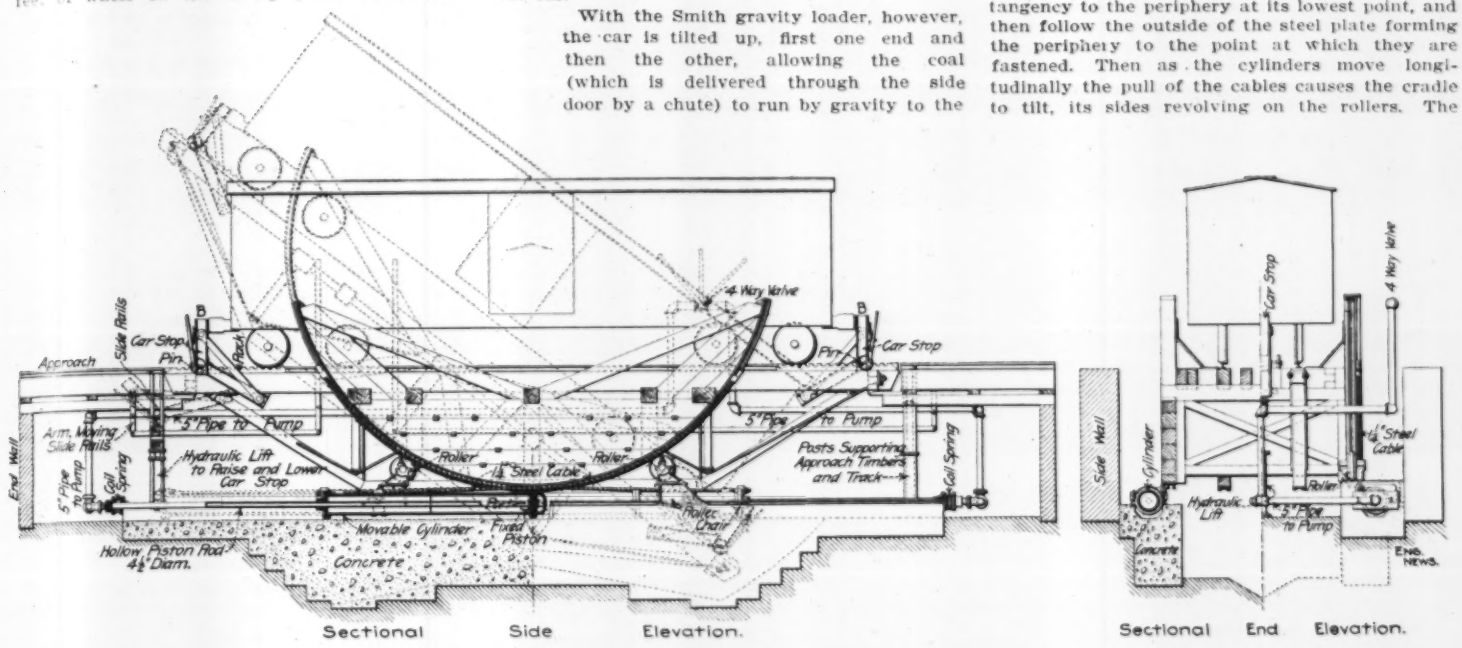

FIG. 1. TILTING CRADLE FOR LOADING COAL INTO BOX CARS.
S. Kedzie Smith, M. Am. Soc. C. E., Castle Gate, Utah, Inventor.

This would increase the flow of the river 323 sec. ft. if it escaped uniformly. Thus it appears that the constant run-off would be increased something over 0.3 sec. ft. per square mile for an unusually dry period of 35 days. Periods of drouth of such length are very rare in the section under discussion, and consequently the computed increment should be considerably more than estimated. Evidently any increase of constant run-off approximating 0.3 sec. ft. per square mile would greatly affect the maximum and minimum flow of a river.

The date upon which the foregoing arguments are based have been derived from years of experience and observation on the prairies and from an intimate acquaintance with the rivers flowing through them. Obviously estimates based on them may contain a large per cent. of error. However, the writer is certain that they contain enough truth to fully demonstrate the theory that cultivation and especially pasturage and drainage are the cause of accentuated maximum and minimum stream flow in the humid prairie states.

MACHINE FOR LOADING BOX CARS WITH COAL.

One of the most troublesome problems connected with the operation of coal mines situated upon railways requiring the use of box cars for shipping the product has been, until the last few years, the loading of the coal into the cars. With four men in a car, only about 300 tons per day can be loaded, so that a mine wishing to ship more than this tonnage in box cars, must have a number of tracks devoted to this class of equipment, which complicates the design of the tipple; and from 3 to 5 cts. per ton is said to be added to the cost of production. The cost and delay to the mine required to load box cars by hand has led to the design of mechanical loaders, particularly within the past eight years; and several styles of loaders are now in use.

With the exception of the gravity loader, described further on, each of these box-car loaders consists of a mechanical contrivance which is put into the car through the side door. With the Ottumwa loader the coal is pushed towards the ends of the car with a slow motion. With the Ramsey loader the coal is thrown towards the ends by a rapidly vibrating beam having an iron head (shaped like a miniature snow-plow) on the inner end, while the motion is imparted by a steam engine connected to the other end. The Victor and the Christy loaders consist primarily of a rapidly running metallic belt, which imparts its velocity to the coal, throwing it to the ends of the car.

With the Smith gravity loader, however, the car is tilted up, first one end and then the other, allowing the coal (which is delivered through the side door by a chute) to run by gravity to the ends, no mechanical contrivance whatever being placed in the car. The idea originated with the inventor in 1898, and the first loader was installed in 1900 at a mine belonging to the Northern Pacific Ry. at Roslyn, Wash. The construction of the loader is clearly shown in the drawing, Fig. 1, and Fig. 2 shows a car in tilted position. The structure upon which the box car is placed is called the cradle, and, so far, has been made of timber. The two sides of the cradle are segments of circles, the periphery being shod with a ½-in. plate 12 ins. wide, to the outside of which are riveted two T-rails of about 60 lbs. per yd. The cradle is supported by two rollers, A, on each side, and the rollers are in turn supported, through suitable bearings and cast-iron chairs, by the masonry foundation.

The tilting motion is imparted to the cradle by means of two horizontal hydraulic cylinders. The pistons and piston rods are fixed and therefore the cylinders move longitudinally when water is pumped into them, each cylinder being carried on two pairs of small wheels. The cylinders are connected to the periphery of the sides of the cradle by 1¼-in. steel cables, which extend from the ends of the cylinders to a point of tangency to the periphery at its lowest point, and then follow the outside of the steel plate forming the periphery to the point at which they are fastened. Then as the cylinders move longitudinally the pull of the cables causes the cradle to tilt, its sides revolving on the rollers. The cradle rides upon the rollers through the two T-rails which are riveted to the rim plate. These rails are placed with the flanges in contact, which leaves a space of about 1½ ins. between the heads of the rails. The rollers are cast with a central circumferential rib which fits into the space between the T-rails, thus holding the sides of the cradle in place upon the rollers.

The method of operating the loader is as follows: The car stops, B, are drawn back and dropped below the level of the track rails into the position shown by the broken lines, and the box car is run onto the cradle, which is laid out on a grade of 2% to facilitate the moving of cars by gravity. When the car has reached the center, the brakes are set, the chute inserted in the door and the dumping of coal begun. The car stops, which are lowered and raised by vertical hydraulic cylinders placed below the track, are raised to their positions above the track and are pushed up against the couplers of the car and then, by

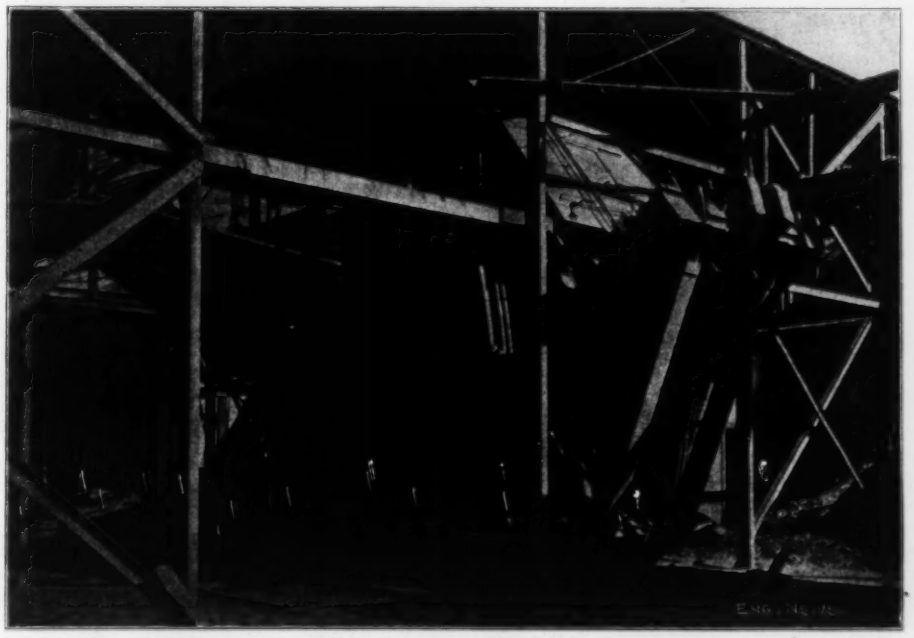

FIG. 2. LOADING COAL INTO BOX CAR ON SMITH TILTING CRADLE.

means of the lever and elbow shown at the rear of the stops, are lowered so that the pin at the wide angle of the stops fits into the grooves of the two cast-iron racks, one on each side of the stop. The resultant of the forces against the stop takes such a direction with reference to the racks that the greater the pressure against the top of the stop the more firmly it is held in place. By the time the stops are set the center of the car is filled and tilting must be begun.

Hydraulic pressure is furnished by a duplex steam pump, 16 × 18½ × 12 ins., the maximum pressure required being 250 lbs. The direction of the flow of the water is controlled by the four-way valve, which is so arranged that the lever is thrown towards the end of the cradle it is desired to tilt down. When the lever is in a vertical position it shuts the water off from the cylinders, and the pump (which is provided with a relief valve) may always be kept under motion and the pressure of water maintained continuously. Assuming in the drawing that the lever is thrown to the right, the water goes from the pump, through the four-way valve and the 5-in. pipe running from it, and enters the cylinders through the fixed piston rods, which are hollow and are provided with ports placed close to the piston. The left half of the cylinder, in this case,

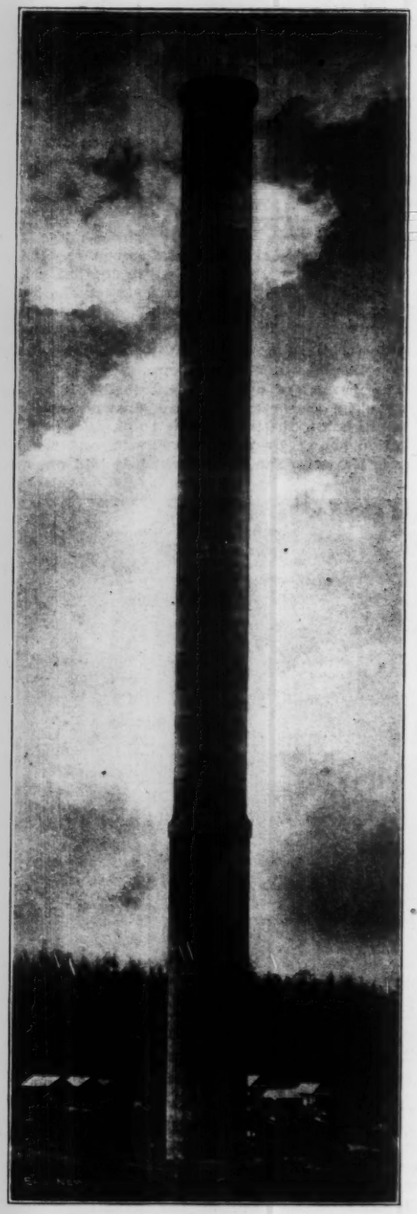

Fig. 1. 300-ft. Chimney of Reinforced Concrete; Tacoma Smelting Co., Tacoma, Wash.

fills with water, causing the cylinder to move longitudinally to the left, and this, in turn, causes the right-hand end of the cradle to tilt down. The movement of the water in the other end of the cylinder is in the opposite direction; it goes from the cylinder through the ports and hollow piston rod and pipe, and through the other side of the four-way valve into a tank, from which it is used over and over again. The actual amount of water wasted is merely that due to leakage.

The speed of tilting is absolutely controlled by the lever of the four-way valve, and the cradle can be held tilted at any angle by merely throwing the lever to a vertical position. As the coal is dumped the car is slowly tilted up to its maximum of about 37°, where it is held until the lower half is filled. When the first half of the car is filled it is brought rapidly back to the horizontal position, and tilted in the opposite direction just fast enough to cause the coal coming from the chute to roll down to the bottom of the car over that already deposited. The tilting is continued until the coal blocks itself against the end of the car, which is then tilted to the maximum and dumping continued until the car is fully loaded. The cradle is then brought back to its horizontal or normal position; the car stops are lifted out of the grooves in the rack by depressing the levers, pulled back off the cradle and on to the tops of the vertical hydraulic cylinders, and lowered below the track. The slide rails for supporting the ends of the stringers of the cradle are then slid under the latter, and the loaded car is run off.

It is often asked what means are taken to prevent the coal in the end of the car first loaded from running down into the other end when that end is lowered. There is no mechanical contrivance to prevent this, but we are informed that no trouble is experienced on this account. The second end of the car is tilted slowly till the coal blocks itself against the end, when it can be tilted to almost the maximum without the coal running down from the upper end; then again, the coal coming from the chute has such a velocity that it will continue to run down a slope much too flat for coal to start down from a standstill.

This loader is considerably more expensive to install than any of the others mentioned, but the following advantages are claimed for it: (1) It has no rapidly-moving parts and the cost of repairs and delays is trifling; (2) as many box cars can be loaded in a day as open cars; (3) there is no breakage to cars and the breakage to the coal is a minimum; (4) only one man is required to run it. There are seven of these machines at present in successful operation; two installed by the Northern Pacific Ry. Co. at its mines in Washington; two by the Crow's Nest Pass Coal Co., at Fernie, B. C.; two by the Carney Coal Co., at Carneyville, Wyo., and one by the Consolidated Coal Co., of St. Louis, at Staunton, Ill. One is now being built for the Union Pacific Coal Co. at Rock Springs, Wyo. The two machines at Carneyville are placed side by side, and are supplied by water from one pump. One man operates both machines, and both cars can be loaded at the same time.

The box-car loader was invented and patented by Mr. S. Kedzie Smith, M. Am. Soc. C. E., at present General Superintendent of the Utah Fuel Co., Castle Gate, Utah. It is manufactured by the Duncan Foundry & Machine Works, of Alton, Ill., for the handling of bituminous coal in the United States, and by the Dodge Coal Storage Co., of Philadelphia, Pa., for the handling of anthracite coal in the United States and for use in Canada.

A 300-FT. CHIMNEY OF REINFORCED CONCRETE.

A reinforced concrete chimney 300 ft. high has recently been completed near Tacoma, Wash., to carry off the smoke and gases from the smelting plant of the Tacoma Smelting Co. (owned by the American Smelting & Refining Co.) Fig. 1 is a view of the completed chimney, and Fig. 2 shows some of the details. The inside diameter is 18 ft. from bottom to top, and at the bottom is an opening or smoke arch 10 ft. wide and 26 ft. high. For a height of 90 ft. there is a double shell, composed of a 9-in. outer wall and a 5-in. inner wall, separated by a 4-in. air space, with air inlets at the bottom. At 90 ft. there is a collar with expansion joint, and above this there is a single shell 7 ins. thick. At the top there is a lead lining to a depth of 20 ft., and this extended over the cap or coping.

The foundation is 39 × 39 ft. on the base, 6 ins. thick, and the concrete is reinforced by rectangular network of steel bars and two sets diagonal bars. The vertical bars of the chim

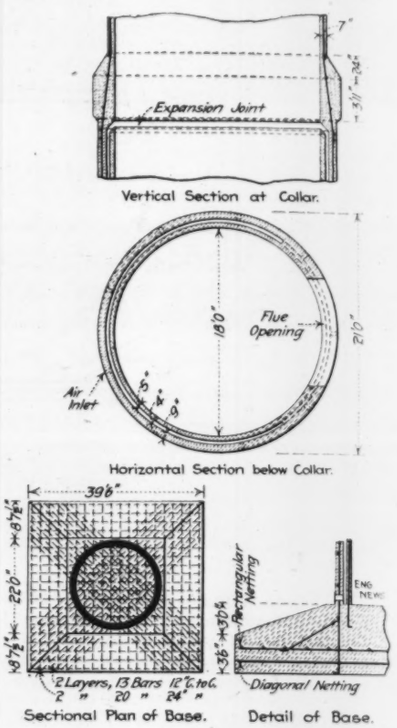

Fig. 2. Details of 300-ft. Chimney of Reinforced Concrete.

are embedded in this foundation, as shown in Fig. 2, and diagonal bars extend from the outer vertical bars to the horizontal bars. For a height of 16 ft. 6 ins. from the base of the foundation there are 380 vertical bars, and the number then decreases at 10-ft. intervals to a height of 180 ft., where there are 60 bars; then 40 bars for 20 ft.; 30 bars for 25 ft., and 20 bars for the remaining 75 ft. to the top. To these bars are attached horizontal steel rings spaced 20 ins. apart in the inner shell, and 36 ins. apart in the outer shell and throughout the single-shell portion of the chimney. The vertical bars are lapped at least 2 ft. at the splices and are interlaced with the bars in the foundation. The foundation bars and vertical bars are steel T's, 1¼ × 1¼ × 3-16-in.; the rings are also of T's, 1 × 1 × ⅛-in. The concrete is composed of 1 part Alsen cement, 3 sand, and 5 gravel for the foundation; for the chimney the mixture is 1 cement to 3 sand. A combination mixer and hoist was used.

The total weight is 1,659 tons (including 75 tons of steel), and the normal pressure on the ground is 1,063 tons per sq. ft. The stress sheet is figured for a wind pressure of 50 lbs. per sq. ft. (equivalent to a velocity of 110 miles per hour), and only the outer shell and single shell are considered in the wind strains, the inner shell having steel reinforcement to take up temperature strains. There is a large factor of safety in both tension and compression, and neither the tensile strength of the concrete nor the compressive strength of the steel are considered. Openings are specially figured, and an excess of strength is allowed in these sections. The foundation is three times the theoretical width and is very heavy, bringing the center of gravity of the whole structure very low.

The chimney was designed and built by the Weber Steel-Concrete Chimney Co., 159 La Salle St., Chicago. Work was commenced Jan. 26 and completed May 1, 1905.

ENGINEERING NEWS

A Journal of Civil, Mechanical, Mining and Electrical Engineering

Published every Thursday by

THE ENGINEERING NEWS PUBLISHING CO.

220 BROADWAY, NEW YORK

BRANCH OFFICES

CHICAGO: 1636 Monadnock Block
SAN FRANCISCO: Rialto Building
BOSTON: 170 Summer Street
ATLANTA: Austell Building
RUDOLF MOSSE, BERLIN AND HAMBURG, GERMANY

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Within the past year or so copper sulphate has brought relief to many a water-works superintendent worried over tastes or odors due to vegetable growths in his storage reservoir. But many surface supplies are drawn from rivers, and in numerous instances it appears that bothersome tastes and odors occur in these, particularly in winter. Whatever the cause of these odors may be, it is evident that their origin is almost, if not always, beyond the control of the water-works official. His remedy, it would appear, must be remedial rather than preventive; or, in other words, when the water at his intake is bad, he must try to devise some method of removing the taste and odor, rather than to prevent its development. In another part of this issue may be found some interesting testimony regarding tastes and odors in numerous river waters. This testimony throws little or no light upon what can be done to relieve existing conditions, but it indicates that the evil is widespread and may have a bearing upon the choice of future water supplies.

The great blast at the Portsmouth Navy Yard, described in this issue, is probably the largest submarine dynamite blast ever fired. The removal of Flood Rock, commonly called the Hell Gate blast, in 1885, was a larger piece of submarine work, but most of the explosive used was rackarock. In the final charge there were 240,400 lbs. of rackarock and 43,300 lbs. of No. 1 dynamite, which broke 270,700 cu. yds. of rock. It will be noted that approximately 1 lb. of explosive was used to break 1 cu. yd. of rock. The rock was mica-schist, and it broke out in large slabs that were dredged with difficulty. On the other hand, in the blast at Portsmouth, the charge was more than 2 lbs. of dynamite per cubic yard of rock. Not only was the weight of the explosive much greater per cubic yard at Portsmouth, but a much more powerful explosive was used than at Hell Gate. It is believed that the resulting shattering of the rock has justified the use of $20,000 worth of dynamite in breaking the 35,000 cu. yds. of trap.

Not only was the blast unique in the amount of high-grade dynamite used, but in the method of drilling the blast holes. It requires no small amount of courage on the part of the contractors to establish a precedent of this kind. Hitherto there have been but two methods of drilling commonly used in submarine work. The older method of the two, and the one used at Hell Gate, consisted in running a series of small parallel tunnels or "drifts" under the area to be excavated. Then from the inside of the tunnels drill holes were driven into the roof and pillars to receive the explosive for the final blast. The other method, and the one now commonly used, consists in drilling vertical holes from a scow, or a platform, on which powerful steam drills are mounted, as described in our issue of July 6 in the article on the harbor work at Buffalo. By this method only shallow holes are drilled. The holes are loaded and fired as fast as they are finished.

The method used at Portsmouth involves the drilling of very long lift holes from inside a pit enclosed by a cofferdam, and the firing of all the holes simultaneously. The method is especially adapted to the removal of islands or promontories that exist in navigable channels, and must be removed to a considerable depth. Where the amount of rock to be taken out justifies the building of a cofferdam it is likely, now that the precedent has been established, that the method used at Portsmouth will be heard from again in submarine excavation of similar magnitude.

The plans for the steel superstructure of the Manhattan Bridge at New York City, which we publish in this issue, deserve more than passing attention. As will be remembered by many of our readers, this is practically the third set of plans that has been prepared for this structure. When the bridge was first projected it was designed as a wire cable suspension bridge, and plans were well advanced on this assumption. A change in the administration of the city, however, brought in a commissioner of bridges with other ideas, and under his direction work on the original plans was abandoned and new plans made which called for a chain cable suspension bridge. The novelty of these plans and the controversy which they aroused between the commissioner of bridges on one hand and the advocates of wire cables on the other hand are still fresh in the minds of engineers. It will also be recalled that a second change in the administration of the department of bridges settled this discussion by placing in office a commissioner and chief engineer who were advocates of wire cable construction. Although the plans for a chain cable bridge had been fully completed and bids for construction invited, they were abandoned by the new administration and work was begun on an entirely new set of plans, which are the ones we illustrate this week. Altogether the procedure of getting this great and much-needed bridge in process of construction has not been a dignified one, and engineers will feel a sense of gratification that finally a plan of construction has been decided upon and will be carried out, particularly since it promises an unusually efficient and handsome structure.

Engineers will naturally compare the Manhattan Bridge with its sister structures across the same stream, namely, the old Brooklyn Bridge and the recently completed Williamsburg Bridge. Both of the older structures are of longer span, 1,595 ft. and 1,600 ft., respectively, than the Manhattan Bridge, which is only 1,470 ft. between towers. Neither of the older structures has, however, the traffic capacity of the new bridge. Reduced to single deck structures of equivalent net widths, the three bridges compare as follows: Brooklyn, 73 ft. wide; Williamsburg, 137 ft. wide; and Manhattan, 170 ft. wide. The greater traffic capacity of the new bridge and the suspension of the side spans from the cables made necessary cables 20½ ins. in diameter as compared with 18⅝ ins. for the Williamsburg Bridge and 15⅝ ins. for the Brooklyn Bridge. Obviously these comparisons might be carried much farther, but it is scarcely worth while to take space for them here. One or two broad differences deserve notice. The first of these is the extensive use of nickel steel and the adoption of galvanized wire for the cables. No nickel steel was used in the Williamsburg Bridge, and the cables were made of plain wire. Another difference that will strike engineers is the simple web systems of the stiffening trusses as compared with the triple intersection lattice trusses of the Williamsburg Bridge. This we think has had much to do with the gracefulness of the main and side span lines of the new bridge, and it brings us to the consideration of what strikes us as the most distinguishing difference between the two bridges. It will be generally admitted we think that the drawings of the Manhattan Bridge depict an unusually graceful suspension structure. There will doubtless be those who will compare its steel towers unfavorably with the monumental masonry towers of the old Brooklyn Bridge, but while we stand second to none in admiration of that magnificent work, we must confess that the all-steel superstructure of the Manhattan Bridge appeals to us as more consistent and quite as graceful in outline. Compared with the Williamsburg Bridge, the new structure shows superiority from every viewpoint of aesthetics. The framework towers, the deep sag of the main span cables, the relatively straight lines of the back stays, the independent support of the side spans, and the "heavy" appearance of the stiffening trusses all contribute to the ungraceful appearance of the Williamsburg Bridge and are all avoided in the designs of the Manhattan Bridge. Whatever there may be to be said as to the relative economy of the two structures, there is no doubt that New York City is getting a much handsomer piece of work in its latest East River suspension bridge than it did in the second one constructed.

"MECHANICAL EFFICIENCY" IN THE GAS ENGINE.

Within the last few months an interesting discussion has been going on among mechanical engineers and thermodynamic authorities in Germany concerning the meaning of the term "mechanical efficiency" in the case of gas engines, especially two-stroke engines. It is surprising, at first thought, that such a widely-used and apparently well-known term as "mechanical efficiency" should give rise to much serious discussion at this late date. Mechanical Efficiency means, and has always meant, but one thing: the ratio of the useful work obtained from a machine to the work applied to the machine. But it immediately becomes evident that this definition does not fully meet the requirements of the case. Gas or steam engines (unlike the lever, the rope-tackle or the gear-train) are not merely elementary "machines" or combinations thereof. They are energy converters, not merely potential transformers. Energy is supplied to them in the form of heat, chemical energy, or the like, and is delivered by them as mechanical work. In the conversion there are involved two distinct sets of actions: thermodynamic and mechanical; correspondingly the total energy efficiency of the engine is made up of two parts, a Thermodynamic Efficiency and a Mechanical Efficiency. While these two parts are susceptible of sharp separation and delimitation by "ideal" definition, their separation in any practical case is rather uncertain; and necessarily so, since the two kinds of action overlap in location and often also in nature. Throttling, and the rounded corners of the diagram which result, is a patent illustration. It is this fact that gives rise to uncertainty in the meaning of Mechanical Efficiency, and that indirectly was at the bottom of the discussion referred to. The origin of that discussion is rather amusing, but, as a brief review will show, the subject is not only complex and interesting, but is also of some considerable importance, partly from the theoretical and partly from the practical viewpoint.

The advantages which we derive from the use of efficiency figures result from their giving us a knowledge of how close the performance of our machines approximates to the ideal perfect economy. Suppose a given rope-and-pulley has an efficiency of 90%; that is, of every 100 ft.-lbs. of work applied to the machine, the amount of 10 ft.-lbs. is irrecoverably lost. Another rope-and-pulley, apparently identical with the first one, shows on test 95% efficiency. Other things being equal, the second machine is the better; it wastes less work, or, to put it more directly, it will yield a given output of work with a smaller input,

and is therefore cheaper to operate. The artisan did better work in constructing the second machine. Of course, a 100% efficiency is the unreachable ideal of such a machine. The conditions are different, however, and also more complex, in heat-engines, where other actions beside the mechanical are involved. The result in a given case is dependent on the excellence of workmanship and on the nature of the machine's action jointly. Given ideally perfect materials and ideally perfect workmanship, a given type of machine still wastes a large part of the energy supplied to it: its efficiency is far from 100%. Indeed, even with perfect materials for the thermodynamic action, under ideal conditions, the efficiency will still be quite low. That is to say, once we adopt a given thermodynamic action, the ideal perfect efficiency is fixed at a point well below 100%. This at once establishes a radical distinction between these engines and the "elementary machine." Two engines whose action is of identical nature and whose workmanship is equally good may show a large difference in performance if one of them accomplishes its thermal or chemical action to better advantage than the other. In order that such differences may be studied, it is necessary that the performance of the engine should be separable into its components, and that the thermodynamic efficiency and the mechanical efficiency should be separately known. Still more important is this in the case where two different systems of action are compared. One system, we will suppose, enables a higher thermodynamic efficiency to be secured than another system, but the second system makes it possible to obtain good workmanship or durability, or otherwise satisfactory construction, with less difficulty or at lower cost than the other. Here it becomes essential to have an accurate separation of thermodynamic and mechanical performance, in order that a machine of one system can be fully compared with a machine of the second system.

There is a practical reason which is of much moment in giving importance to the subject of discussion. It is very desirable that the term "mechanical efficiency" should have a single, fixed, meaning. Gas engines of, say, the two-stroke type are made in large numbers by various manufacturers. If two or more definitions of "mechanical efficiency" are current, each maker will publish and claim efficiencies calculated under that definition which gives the highest figure for his production. Misunderstandings and meaningless confusion would result from such a situation. In steam-engine practice a single definition for mechanical efficiency (brake horse-power divided by horse-power computed from the full area of the indicator card) has long ago become standard, and opportunity for misunderstanding is rare. In gas-engine practice it is desirable that a similar convention be reached. The German discussion reviewed in the following, resulted from this motive.

At the last annual meeting of the Verein Deutscher Ingenieure, Professor A. Riedler of Berlin in the course of a long lecture on "The High-Power Gas Engine" had occasion to compare the modern two-stroke and the four-stroke gas engine with reference to efficiency. This led him to severely criticise a method of computing mechanical efficiency of two-stroke engines, which, he said, had been put forth in a recent test report. In that report, Indicated Horsepower had been determined by subtracting Pump Horsepower from Cylinder Horsepower; Mechanical Efficiency was, of course, found as Brake Horsepower divided by Indicated Horsepower. The report referred to was one made by Professor E. Meyer, of Berlin, to the firm of A. Borsig, on a 500-HP. Oechelhaeuser engine (of the two-stroke type), which showed a full-load efficiency, calculated in the manner noted, of 0.82 to 0.84. Had the mechanical efficiency been computed on the basis of Indicated Horsepower equals Cylinder Horsepower, the efficiency would have been seven or eight per cent. lower. The report stated clearly the method used for computing efficiency, and while in its tabular summaries it gave the values of efficiency and also the values of heat consumption for both methods of computation, yet it presented the higher efficiency figure, the one calculated on Net I. HP., as the true "mechanical efficiency."

The society before which this lecture was read held that the criticism advanced in Professor Riedler's lecture was so severe as to call for an official investigation. It therefore appointed a committee composed of Professors R. Schöttler, M. Schröter and A. Stodola, to determine whether or not Professor Meyer's test report contained "erroneous and misleading statements," as had been charged. The findings of the committee (which, with Professer Riedler's lecture and the criticised report of Professor Meyer, were published in the "Zeitschrift" of the society of Feb. 25, 1905,) are to the effect that Professor Meyer's report contains nothing that is erroneous or that would tend to mislead anyone thoroughly conversant with the subject. The committee specifically disclaims, however, the duty of examining whether Professor Meyer's method of determining mechanical efficiency is to be considered "scientifically well-founded with respect to the general theory of heat engines;" nevertheless, their report gives the impression that, had they been charged to examine this matter, they would have inclined to the side of Professor Meyer rather than to that of Professor Riedler.

These preliminaries opened the way for a discussion of the real matter at issue: the definition of Mechanical Efficiency in the case of the two-stroke gas engine. Professor Riedler came out with a strong defense of his views, which are: (1) that Indicated Horsepower in such an engine is the power developed in the working cylinder, and (2) that the work consumed by the pumps is part of the resistance of the engine. For a given engine his method of calculation shows a greater output in indicated horsepower, a lower heat consumption per indicated horsepower, and a lower mechanical efficiency, than the method which he opposes. He recognizes that the fundamental quantities involved in the dispute are Work Applied and Work Delivered, the nature of the former quantity being the real point at issue. In steam engine practice, work applied is by common consent identified with area of indicator diagram; gas engine practice should agree with this. The factor which reduces the mechanical efficiency is not the mere frictional loss in the mechanism, but its total resistance, of which the pump resistance is a part. In the four-stroke gas engine, theory may perhaps permit the negative loop of the suction stroke to be deducted from the positive area of the indicator diagram in finding indicated horsepower, although in practice such a procedure has no meaning due to the very great difference in area of the two loops. But even though the subtraction be held theoretically correct in the four-stroke engine, it does not follow that the pump work of the two-stroke engine is to be similarly subtracted; for suction in the four-stroke engine and pump work in the two-stroke engine are radically distinct, not only in character and localization, but also in importance. The suction resistance in the four-stroke engine will not be higher than 4% of the cylinder power while the charging work in the two-stroke gas engine will lie anywhere between 15 and 50% of the work developed in the cylinder. The case of the charging pumps in the two-stroke engine is somewhat similar to that of the air pump in a steam engine: when the air pump is part of the engine its power consumption is never deducted from the cylinder power to give indicated horsepower, and, correspondingly, such a deduction is not admissible in the case of the two-stroke gas engine. In conclusion, Prof. Riedler holds the strongest argument against Prof. Meyer's method to be this: Mechanical Efficiency is universally taken to be a measure of how effectively the engine utilizes a given thermodynamic action; yet, if calculated by Meyer's method, no material decrease in efficiency is shown when a poor pump is substituted for a good pump, so that the performance of a vital part of the engine is le... considered in the application of the metho...

Professor A. Stodola, of Zürich, a member ... committee, next appeared in the forum. H... ognizes that the question is complex, bu... cludes that Meyer's method is the preferab... In the four-stroke gas engine and in the ... condensing steam engine, the back pressur... is automatically subtracted in the indicator ... gram when finding indicated horsepower. ... mechanical losses in these cases, therefor... clude only engine friction. In the condensin... gine, practice is somewhat incongruous: the ... pump work is not subtracted when the pu... driven by the engine; but it is subtracted ... the air pump is separately driven. In the ... stroke gas engine no custom has yet become ... eral, and in other types of heat engine the m... is still less settled. In the two-stroke engine ... pump may have one or both of two functio... (1) to overcome losses in throttling and fluid f... tion, thereby increasing the engine capa... without affecting its thermodynamic action; (2) ... to produce compression of the charge, thereby ... altering the thermodynamic action. If the f... mer, then its power consumption is directly an... ogous to the negative loop in the steam engine ... diagram, which, it is known, is subtracted from ... the positive loop, being considered a thermody... namic loss rather than mechanical loss. If, however, the pump has the function of producing initial compression of the charge, then it does work upon the gas, which is returned in the working cylinder as part of the energy produced. The "work applied" by outside means, i. e., the gas, is then necessarily the difference between the total energy developed in the working cylinder and the energy added by the pump. In all cases, therefore, Professor Stodola concludes, the pump power in the two-stroke gas engine should be subtracted from the cylinder power to give Indicated Horsepower. It may be perceived, from these arguments, that Professor Stodola's views are dominated by their origin in the idea that mechanical losses include only engine losses proper, that is, friction losses.

Professor Schöttler, another member of the committee, also expressed his opinion on the subject. He sees some merits on each side of the controversy. He refers to the fact that Clerk in the case of the Brayton (constant-pressure) gas engine and Schröter in the case of the Diesel engine had previously adopted the practice of subtracting charging work from cylinder work to obtain indicated work. As a more striking example of how special cases require special procedure, he refers to the Rider hot-air engine. Here we have two different cylinders permanently connected, with equal pressures but different volumes; the diagram from neither cylinder gives indicated power, but a third diagram must be calculated as the difference of the two in order to obtain "indicated work" and mechanical efficiency. Here, of course, the two cylinders being permanently connected, the engine has virtually only one cylinder. It would be questionable whether any conclusions for the two-stroke gas engine could be based on the practice necessary in the case of the hot-air engine. Each case, therefore, must be considered by itself. Prof. Schöttler then proceeds to divide pump work, just as did Professor Stodola, into compression work and what may be called mere shifting work. If the pump does compression work, he believes that it should be subtracted from the cylinder work in computing indicated horsepower, since the "work applied" by the gas itself is less than that obtainable from the compressed charge; but if the pump is required to do only shifting work, then the question whether its energy consumption is a mechanical loss or a thermodynamic loss is open for argument. Professor Schöttler seems to incline to the belief that such shifting work should be viewed as a mechanical loss, and therefore should not be subtracted from cylinder horsepower. As an ideal solution of the whole difficulty, he would base the consideration of all questions like that under discussion on a universally-applicable defi-

nition of indicated power: Indicated power is the power developed in a closed system equivalent to the given system. He cites the fact, as did Prof. Riedler, that the method of Prof. Meyer gives no adequate indication of the efficiency with which the pumps perform their work, since by that method a very great drop in pump efficiency will have an almost imperceptible effect on the calculated mechanical efficiency; thus, the method affords no index of the working of the engine unless heat consumption per indicated horsepower be in all cases also determined and stated. However, as long as the separation of shifting work and compressing work cannot be carried out, he concludes the only way by which Indicated Power can be computed is the algebraic summation of all indicator diagrams obtainable from the engine.

Among other contributions to the discussion, we may note opinions advanced by two other well-known authorities, Mr. Rudolf Diesel and Mr. H. Güldner. The latter takes definite position on the side of Prof. Riedler, and claims that both in the four-stroke and in the two-stroke engine the positive area alone should be calculated as I. HP. In the case of the former, he asserts, it is in practice not feasible to obtain the negative loop (light-spring diagram), except in isolated cases; moreover, the negative loop has no relation to the thermodynamic action but depends only on constructional features of the engine, so that its area represents a pure mechanical loss. In the case of the two-stroke engine, the charging-pump work should strictly be separated into shifting and compressing work; but as this is hardly feasible, and the shifting work is the larger of the two, it appears necessary to conlude that pump work may not be subtracted from cylinder work and that the latter alone represents indicated work.

The position of Mr. Diesel on the question immediately under discussion is in support of Prof. Riedler's contentions. The argument is that mechanical efficiency should represent the ratio of ultimately utilizable power to the power indicated in the cylinder, no matter what the source of that power; the latter may be obtained from boiler, gas producer, or the like, and may be modified by superheaters or condensers, or by charging or scavenging pumps, etc. But while the value of efficiency thus computed may be enough for the purposes of buyer or owner, the designer requires another figure, as he is interested in knowing where the indicated power is consumed. Part is employed in driving pumps, etc., another part appears at the flywheel, another part is lost in friction. The sum of the first and second parts constitutes a mechanical power which, divided by indicated power, yields a figure for efficiency which Mr. Diesel would call Dynamic Efficiency, and for which he claims a large importance. He suggests terms and definitions as follows: (1) Indicated power, the power represented by the indicator card of the working cylinder; (2) Useful power, that appearing at the flywheel for external use; (3) Effective power, the sum of useful power and power consumed by pumps, etc.; (4) Mechanical efficiency, useful power divided by indicated power; (5) Dynamic efficiency, effective divided by indicated power; (6) Pump factor, pump power divided by indicated power; (7) Friction factor, the difference between 100% and dynamic efficiency. These suggestions, evidently, add new complications to the already complex discussion; but they also serve to show, especially if they are considered in connection with all the various types of heat engine that have been constructed, that a complete unification of terminology and definition in the subject is by no means easy.

There is material in this discussion for considerable reflection on the part of everyone interested in mechanical engineering problems. Both on grounds of theory and on grounds of practical value there is something to be said on both sides of the controversy; it is not a dispute between theoretical considerations and practical considerations, but a disagreement based on various matters of both kinds, involving constructive principles and thermodynamic principles in an intricate manner. First, practical considerations are in disagreement: On the one hand, it is desired to make mechanical efficiency an index of workmanship, so that resistances shall include only the machine friction; Meyer's method seems correct. On the other hand, it is desired to make indicated power a measure of cylinder capacity, and Riedler's method seems correct. Again, theoretical reasoning may lead to opposite conclusions: On the one hand it is apparent that we supply energy to the cylinder in the form of gas, and we further infuse energy into this gas by the pump compression; the true applied work should take account only of the original gas energy, and therefore the pump work should be subtracted from the cylinder work to give indicated power; Meyer's method seems correct. On the other hand, we generally hold that indicated power should be a measure of the thermodynamic action going on in the cylinder—the transformation of other forms of energy into mechanical work; of the equality between pump work and the thermodynamic gain by compression we know nothing, but we do know that in designing large-capacity two-stroke engines an added resistance, the pump resistance, is voluntarily incurred in order to secure a thermodynamic gain. The gain should appear in lower heat-consumption per unit of power, and the added resistance should appear in lowered mechanical efficiency, as actually shown by Riedler's method. Thus, theoretical and practical comparisons in considerable number might be drawn, favoring alternately one side and the other of the controversy. It is on this account that the question, apart from all practical considerations, is interesting in the sense of affording entertaining reflection.

The fact is worth noting as peculiarly appropriate that this question should have come up at the present time, when high-power gas engines are winning a large field of utilization, and that it should have first crystallized into a public discussion in Germany, the country where this branch of engine-building has received the fullest attention. When engines of only small power are concerned, such a question as the present one could hardly arise except in an academic way. It has been noticed and discussed in that way in the past (as for example in a test of a 15-HP. Mietz & Weiss engine, reported in Engineering News of Sept. 15, 1904, where, however, the closed crank-case acts as charging pump, and compression of the charge is distinctly not involved); but mechanical efficiency figures do not become vital until large units rise to commercial importance. When this stage is reached it becomes highly desirable that mechanical efficiency should everywhere mean the same thing, and an approved definition and method of calculation must be fixed, by practice or by specific action on the part of technical societies or the like. While the discussion under review is, therefore, quite appropriate, its magnitude and serious tone are somewhat surprising. We imagine that in this country, even were the industrial condition of gas-engine building similar to its present condition in Germany, a discussion of such volume and intensity upon a question of principally theoretical interest would be impossible. The technical mind operates in different manner in the two countries.

To close this review of the question, we venture a partisan opinion in order to further stimulate, if possible, consideration of the subject by those of our readers who interest themselves in mechanical matters. The fundamental matter at issue is: What are the mechanical power losses in the two-stroke gas engine? A general answer would be: They are all the mechanically-measurable losses which takes place in the mechanism proper, beginning with the cylinder, and neglecting all auxiliaries. If the air and gas pumps of the two-stroke gas engine constitute integral parts of the mechanism, then their energy consumption should be included in the losses, and cylinder horse-power as given by the working cylinder indicator diagram should give the proper basis for computing mechanical efficiency; this agrees with Professor Riedler's view. On the other hand, if the charging pumps are viewed as auxiliaries which furnish part of the power developed in the cylinder, then, certainly, the total "work applied" to the engine is produced by the gas charge in combination with the pump compression resulting in the cylinder indicator diagram, which latter is a measure of applied or indicated power. This again agrees with Riedler's method. In this case, however, the work delivered to the pumps must be viewed as part of the output. The contrary view encounters difficulties in the case where the charging pump of the engine is driven by external power—a case which is by no means beyond the realm of imagination. In such a case it is quite possible, by raising the pump work well beyond the friction losses in the gas engine mechanism, to produce conditions where Professor Meyer's method of computation would show the gas engine to have an efficiency exceeding 100%. The transition to this case from the case where the pump is driven by the engine itself involves no radical change of principle, and the same argument should apply to both cases. The mere possibility of securing a mechanical efficiency figure of 100%, or over, is repugnant to common sense and argues against the use of any method permitting such a possibility. This again speaks in favor of Professor Riedler's method, in which, as far as we know, such a possibility does not exist. It would seem, then, that in both views, whether the charging pump be considered as an integral part of the engine or as an auxiliary mechanism, Indicated Horsepower should be identical with Cylinder Horsepower determined from the indicator diagram, and mechanical efficiency should be based on this value.

LETTERS TO THE EDITOR.

Some Pernicious Forms of Graft in Engineering.

Sir: It has occurred to me that some remarks on "graft" in engineering matters might be timely. We do not believe that there are any more rascals in engineering than in other lines, and we think that human nature is about the same, irrespective of the profession or business; but some lines do give better opportunities than others, and engineers and architects do have very unusual opportunity for graft. Sometimes we feel humiliated by letters which are sent to us by parties who do not know us, and who apparently think it all right, and a matter of course, to offer us a commission. When we started in business, it seemed that nearly every manufacturer's representative made such offers; but now they come mainly from parties who have not met us, or apparently never met any of the men who made such offers verbally. Some of the offers are made without any attempt at concealment, others in a roundabout way. For example: we recently received a letter from a New York concern sending us a catalogue and discount sheet, and stating that there would be an additional allowance to us of 10%. We replied that we were engineers and not contractors, hence the 10% discount did not interest us, as we wanted to obtain the lowest possible price for our clients. The concern replied that it noted we did not wish to take advantage of its 10% discount to us *as engineers.*

The argument which has often been used when making such offers is, that the client does not suffer because he cannot buy any cheaper than the regular discount price, and, therefore, he is not being injured, and the engineer is that much better off. We have been informed that in some cases the engineer or purchasing agent accepts such discount, and turns it over to the purchaser, and considers that such action is honest; but it seems to us that in such case it is not an honest transaction with the seller, and it is liable to injure the reputation of the party accepting the commission.

In other cases the bribe comes in the form of a statement that the engineer can be put next to the parties in control, and can be assured the engineering; but in such case, of course, it is expected that one or more of the contracts will be placed with the specified parties.

The above are matters which have come up in our personal experience, and in connection with the purchase of both large and small amounts of material, and in the engineering of propositions of $1,000,000 and more.

We are informed, although this has not been part of our experience, that sometimes officers of trust companies or bond houses stand in with consulting and contracting engineers, the illegal commission being divided; and by illegal we mean any payment not known to all

parties concerned, or that cannot appear on the minutes, or which would have to be covered up.

Another form of bribe with which we have had experience is a statement that certain manufacturers, or contracting engineers, have a large force of engineers, draftsmen, etc., and it is unnecessary for the consulting engineer to take his time, or go to the expense of preparing plans and specifications, as they will only be too glad to do such work for him, and will not make any charge, and will merely do it in order to become well informed as to the proposition, and that the engineer and his clients will not be bound in any way as to the placing of the contract. This sounds well, but if the party making such a proposal did not get the contract it is fair to presume that the proposal would not be made a second time.

We are informed as to one engineer, doing a considerable amount of work, who does not have any draftsmen, or even a stenographer, and we have been told that his plans and specifications are prepared in certain offices, and that all, or at least practically all, of the contracts go to such concerns.

We believe that there are many competent and thoroughly honest engineers and architects, and that the question is, how to get at those who injure the standing of the profession, as it is so easy for such men to cover their illegal transactions that even publication of their accounts (which we would not advise) would not be sufficient.

Yours very truly,

Engineers.

Cleveland, O., July 21, 1905.

(In the same mail with the foregoing communication we received a second one, enclosing a circular which suggests one of the forms of indirect bribery, mentioned above. The letter and circular follow.—Ed.)

Sir: Noting the attached circular, which has been apparently sent broadcast, at least through railroad circles, we presume that you have possibly had a copy of same sent you.

We do not know whether you would care to take any notice of this circular editorially in the Engineering News, but to our way of thinking the circular smacks very much of commission from material men. It may illustrate one of the tendencies of the times, but we think the large percentage of engineers in the industrial world should frown down on transactions of this character.

Yours truly,

Railroad Engineer.

ENGINEERING ANNOUNCEMENT.

The demand on the supply house for sound, practical advice has been gradually increasing. Advice, *while it costs you nothing*, is given by men who are able to speak authoritatively not only in regard to goods of our manufacture, but from a thorough knowledge of engineering practice, and the machinery supplied by other houses.

We beg to announce that we have engaged and keep constantly with us a corps of practical, experienced engineers in each of our departments. . . . . .

These men are at your service on any engineering proposition. We hope that they may be of material assistance to you.

(Signed).....

(Our correspondents have expressed themselves so clearly and forcibly on the highly objectionable and unprofessional practice of giving and taking commissions or their equivalents from manufacturers and supply men that we need say nothing more, further than to endorse their general position.—Ed.)

Computing Bevels with the Slide Rule.

Sir: The following method for computing bevels with the slide rule may be of interest to some of your readers, particularly to bridge and structural draftsmen.

It has been my experience to observe that the slide rule is but little used by draftsmen making shop drawings, but I am sure that if it were used more extensively it would save a great deal of time. If kept conveniently at hand it may be made to save considerable time in figuring rivets, in dividing long dimensions into equal spaces, in checking up dimensions roughly, in computing accurately dimensions by approximating the lengths which have small influence on the final results, and in various other ways which will be suggested to one who continuously uses the instrument.

Bevels up to 6 ins. in 12 ins. can be figured easily, with not more than $\frac{1}{64}$-in. error. In order to use the slide rule for bevels greater than 6 ins. in 12 ins., the writer uses the formula below, which is self-explanatory:

$$\frac{12'' - X''}{12''} = \frac{A - B}{A} \quad \therefore X = 12'' - 12'' \frac{A - B}{A}$$

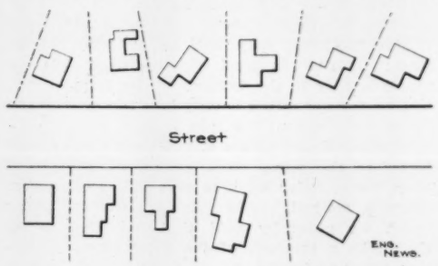
This formula may seem clumsy at first sight, but after it is used two or three times it requires but very little mental effort to perform the operation.

Yours truly, C. N. Haggart.

Ambridge, Pa., July 14, 1905.

A Request for Suggestions on Surveys for Mapping the Location of Buildings on City Streets.

Sir: The best method of locating buildings along a street is a matter of much discussion among engineers. The above sketch is submitted to your readers with a request for suggestions as to the best and most accurate method to pursue in taking the measurements, so as to easily and readily plot them.



Yours truly,

T. R. Ansit.

New York, July 21, 1905.

Low Pulling Portland Cements.

Sir: The data contained in the article on "Low Pulling Early Stage Portland Cement vs. the Ordinary Early Strength-Developing Product," by Mr. W. A. Aiken, in your issue of July 20, 1905, are most valuable, and deserve the careful scrutiny of engineers and of all others interested in the manufacture, the testing, or the use of cement.

The ordinary testing of cement is seldom carried out for a greater period than 28 days, although some manufacturers test their product for periods up to a year or longer, which latter results, however, are seldom published. The article referred to contains tests up to three years, and is particularly important in throwing light on the working of the specification requiring a certain percentage of increase in strength of 28-day tests over 7-day tests. The advisability of inserting or insisting upon such a specification has long been a question of decided difference of opinion between the manufacturer and the consumer of cement, and yet there has been a dearth of published information in regard to the subsequent behavior of cement condemned on account of failure to meet this percentage of strength increase requirement.

The tests published in Mr. Aiken's article are valuable, not only for their comprehensiveness, but because of their source; they were made, not by a manufacturer of any particular brand of cement, but in the laboratory of a consumer, under specifications requiring a minimum increase of 15% in neat strength and 25% in sand strength, in 28-day tests over 7-day tests, the inspection involving several different brands for a total of 2,250,000 barrels.

Figures, especially when obtained under such conditions, are bound to carry most decided weight, not only because of the long time periods involved, but also because of the vast number of tests made on the enormous bulk of material examined. An examination of the data presented in the article reveals the most positive evidence yet presented of the injustice which actually resulted in these cases, and is likely to result in all cases, by an adherence to the "percentage of strength increase" specification quoted.

Cement in work is, of course, never used neat, the behavior with sand being the only true criterion of what can be expected of the cement in actual work; in fact, Mr. Aiken, himself, in the course of the same article, refers to "sand results, which after all, are the most important factors in determining a cement's value."

Quoting from the article, the summary of all the accepted and all the rejected cement of these 2,250,000 barrels, gives results as follows:

Long Time Test of 1:2 Portland Cement Mortars.

	7 days	28 days	3mos.	6 mos.	1 yr.	2 yr.	3 yr.
All accepted cement, lbs....	404	525	568	549	552	523	492
Cement rejected for poor gain at 28 days, lbs.	434	519	538	511	508	505	520

These figures show conclusively that the "percentage fo strength increase" specification resulted in rejecting first-class material—better cement, in fact, than that accepted, the strength of the rejected cement at the end of three years being 28 lbs. greater than the strength of that accepted. The cement accepted showed the decided falling off, at the end of three years, of 33 lbs. from its strength at 28 days, which latter strength in a manner controlled its acceptance, while the cement which was rejected showed no falling off at the end of three years in fact, recorded a slight increase. Reduced to percentage, the accepted cement, while making its required increase of 25% in the short time period of 28 days, lost 6.3% of this strength at the end of three years; the rejected cement, while failing to make the required 25% increase in the short time period of 28 days registered a small percentage gain at the end of three years and was then about 6% stronger than the accepted material. After the three-month period, the maximum falling off in strength of the rejected material at any time during the entire three years was only 33 lbs. while the accepted cement during the same period showed a maximum falling off in strength of considerably more than twice this or 76 lbs.

The publication of comprehensive data of this kind covering as it does thousands of tests, and the careful analysis of the figures recorded, cannot fail eventually to impress engineers with the fallacy of the conclusions sometimes drawn from the comparison of strength tests at the 28 days and the 7 days periods.

Very truly yours, Bernard Enright.

South Bethlehem, Pa., July 21, 1905.

Sir: I note that you published in your issue of July 20 Mr. Aiken's paper on "Low Strength Portland Cement," read before the American Society for Testing Materials at its recent meeting in Atlantic City. This paper will be very widely read and will receive from engineers the consideration which it undoubtedly deserves. As a paper before the American Society for Testing Materials, nearly all of whose members are very familiar with the phenomena of hardening in cements, the paper deals quite sufficiently with the data, but to many engineers who are reached by your paper who have not had and who cannot have an opportunity for looking into the details of cement testing, I believe further comment would be acceptable. Mr. Aiken, of course, knows that he is recording purely conventional tests whose bearing on the mechanical and chemical changes which are going on in the cement he does not take the trouble to explain; and they require some explanation.

(1) Portland cement is a highly sensitive chemical compound, essentially the same in all cases, but considerably affected in its quality by accidental variations: (a) In chemical composition. (b) By methods of manufacture and storage and especially the effects of moisture taken up in various ways. (c) By the mechanical manipulation to which it is subjected. Tests of cement will always show variations in results accounted for by these accidental causes.

(2) The hardening of cement is essentially a process of crystallization or induration by the formation of crystals. A sound cement treated with water gets hard and stays hard. This is all we expect of it. This does not necessarily mean that it shall develop increasing tensile strength with time. It does mean that it should develop increasing crushing strength. I hold, therefore, that long-time tests for tension alone are of no value unless they are supplemented by compression tests. In the formation of a crystalline body two things occur: one is the formation of crystals and the other is the formation of lines of cleavage (which are lines of weakness) between the crystals. In this regard hardened cement is quite comparable to cast iron, having a high compression strength due to the hardness of its crystals and a low tensile strength due to the weakness of their union.

It is necessary, therefore, to point out emphatically that the loss of tensile strength in briquettes after 28 days is quite a normal occurrence established through a very long series of tests by many observers. It generally indicates merely a hardening of the crystals and must not be regarded *per se* as an indication of poor quality. I have just been examining a table of long-time results of Portland cement tests published by the late Prof. Tetmajer of the Zurich Polytechnic Institute. These results extend to one or two years and give both tensile and compression tests of the samples submitted. About one-half the samples show a decrease in tensile strength at some stage of hardening. In compression tests, however, all these specimens show progressive gains with age throughout the table. I am compelled to refer to European tests for this information, because there are very few compression tests on record in this country.

Two things will suggest themselves to anyone who examines Mr. Aiken's table, to wit.: (1) He has reasonably established the correctness of his views in the case of the "Turned-over Cement." (2) He has failed to establish the correctness of his rulings in the case of the "Rejected Cements."

All things considered, the series of tests obtained from the rejected cements is as good as any tests he reports. It is not unfair, therefore, to hold that Mr. Aiken's idea is correct, but his method of carrying it out is not satisfactory. A cement with too great chemical activity, too much "fire" in it, has been found objectionable in many series of tests and has indeed been known in long-time tests to show very much worse results than anything which Mr. Aiken records. It is important to rule this cement out by proper specifications, but I do not know that I am prepared to offer a solution for the problem. I am quite in sympathy with ruling out cements that still have "fire" in them, but I am satisfied, other things being normal, that cement which will show 700 lbs. tensile strength in seven days and 800 lbs. at 28 days is better

than one that shows 400 lbs. in seven days and 500 lbs. in 28 days. Under the specifications of the Rapid Transit Bureau the latter would be accepted and the former rejected. The difference between the two is due to a small difference in chemical composition. Possibly 0.5% in lime would make this difference in tensile strength at seven days and in some cases this small difference of 0.5% in lime would be important to the manufacturer for other reasons. His formula might be a narrow one, requiring the lime to be at or near certain figures. To reject his cement would be a hardship. One of the best plants in the Lehigh Valley district makes cement with this peculiarity. It is really of superior quality, a fact that has been demonstrated during a manufacture of ten or twelve years.

Other things being equal and within certain limits, we want cement which will attain early strength. It suits modern conditions. Portland cement has displaced natural cement because, while the latter may be equally hard at the end of a year, Portland cement gets hard rapidly and permits of continuous work.

My suggestion is that the clause in regard to the increase in strength at 28 days should read so that it might or might not call for rejection at the option of the engineer. This would enable an inspector to exercise discretion with different manufacturers using somewhat different formulas. There should be no difficulty in establishing what tests are normal for any brand of cement and in dealing with it accordingly.

Yours truly, F. H. Lewis.

Room 18, Echols Building, Philadelphia, Pa., July 22, 1905.

ORE UNLOADING MACHINES FOR USE AT RECEIVING DOCKS.

The rapid and economical unloading and handling of iron ore is one of the special features of many of the lake ports, and prominent among the ore unloaders is the Hulett machine, which is shown in the accompanying cuts. It is the invention of Mr. Geo. H. Hulett, Third Vice-President of the Wellman-Seaver-Morgan Co., of Cleveland, O., which is the exclusive builder, and to which we are indebted for information. The machines may be operated either by steam or electricity. Fig. 1 shows the two electrically-operated machines recently erected at Lorain, O., for the National Tube Co.; Fig. 2 shows three electrically operated machines at the ore dock of the Lackawanna Steel Co., at Buffalo, N. Y., and also shows the two Hulett conveyor bridges.

The Hulett ore unloading machine has two main girders at right angles to the face of the dock, supported by steel towers mounted on trucks so that the machine can travel along the dock and be spotted at the hatches of the ore steamers. The towers or legs are usually spaced far enough apart to allow of four lines of track being laid under the machine. Along these girders travels a frame or carriage upon which is mounted a long pivoted walking beam, and from the outer end of this beam is suspended a vertical leg having a scoop bucket at the bottom. Beneath the beam is a parallel motion bar, hinged to the carriage and to the leg. The walking beam lowers and raises the bucket, while the travel of the carriage moves the beam and bucket out to the ship and back to the dock. To reduce the travel of the carriage, receiving hoppers are placed between the main girders, at the dock end of the machine; these discharge either into railway cars beneath, or into a hopper car which runs out on a cantilever frame to dump the ore into cars or a stock pile.

The bucket is of ten tons capacity, and is opened and closed by hydraulic power on the steam machines, or by specially designed motors on the electric machines. Fig. 3 shows the bucket scooping up a load of ore in the hull of the steamer "Augustus B. Wolvin," which is one of the modern ore carriers, having plate girder deck beams with no columns or stanchions to obstruct the hull. The hatches are separated only by narrow strips of deck carried by these girders, and the sides are inclined to form a hopper-shaped receptacle for the ore. The maximum spread of the bucket is 18 ft., and by telescopic motion it can be made to reach from the center of one hatch to that of the next hatch, the suspended leg being mounted in rotating trunnions in the walking beam, so that it can be revolved on its vertical axis and enable the bucket to reach out in any direction. The bucket can also be traversed across the hold by the movement of the carriage from which the leg is suspended. In ordinary boats the machines can reach 90% of the ore, and in some of the modern boats they have actually unloaded 97% without the aid of shovelers. The bucket operator rides inside the vertical leg, close to the bottom, as shown in Fig. 3, and controls all movements of the bucket. Another operator, on the carriage, controls the movement of the carriage and the travel of the machine along the dock, as well as the movement of the bucket car above mentioned.

At the Buffalo plant, Fig. 3, the ore is delivered onto the stock piles by the unloader, and is then handled by two Hulett traveling conveyor bridges of 374 ft. 6 ins. total length, fitted with seven-ton buckets. These buckets dump the ore into a self-propelling hopper which spans two railway tracks upon which run the self-propelling hopper-bottom cars for filling the bins. In this way the conveyor buckets can be kept in continual operation without waiting for the return of the bin cars.

The machines are designed to deliver one bucket load of ten tons a minute. The four machines of the Pittsburg & Conneaut Dock Co., at Conneaut, O. (which are operated by steam) have unloaded 7,257 gross tons in 4½ hours, or over 403 tons per machine per hour, the largest amount taken out in one hour by one machine being 681 tons. There are now about twelve of the machines in operation.

FIG. 1. HULETT ELECTRIC ORE-UNLOADING MACHINES AT LORAIN, O.
Wellman-Seaver-Morgan Co., Cleveland, O., Builders.

FIG. 2. HULETT ORE-UNLOADING MACHINES AND CONVEYOR BRIDGES AT BUFFALO, N. Y.
Wellman-Seaver-Morgan Co., Cleveland, O., Builders.

STEEL FLAT CARS of 150,000 lbs. capacity have been built for the Pittsburg & Lake Erie Ry. for the purpose of transporting heavy castings. There are six fish-belly plate-girder sills, 20 ins. deep at the middle, the side sills being continuous and the center and intermediate sills framed against box girder body bolsters built up of channels and plates. The end sills are 13-in. channels, and there are four transverse 10-in. channels between the bolsters, together with diagonals of 8-in. channels from the corners to the bolsters. The entire framing is covered with ¼-in. deck plates, upon which is a wearing floor of planking. The car is 30 ft. long and 9 ft. 6 ins. wide, with its floor 42 ins. above the rails. It is mounted on diamond-frame trucks with 26-in. steel tired wheels and journals, 6⅝ × 11 ins.; the truck wheelbase is 4 ft. 10 ins. and the distance c. to c. of trucks is 20 ft. The weight is 48,200 lbs. Two steel flat cars of 120,000 lbs. capacity were exhibited by the Pennsylvania Railroad at the Railway Appliances Exhibition at Washington in May. Each was mounted on four trucks, and weighed 59,500 lbs. They are used for hauling such ponderous loads as wire cable, bridge members, guns, etc.

LOCKING BAR JOINTS FOR 32-IN. STEEL WATER MAIN, SYDNEY, N. S. W.

Locking bars instead of rivets continue in favor for the longitudnial joints of steel water conduits in Australia. The latest instance of the use of locking bar joints which has come to our attention is on a 32-in. supply main, nine miles and 423 ft. in length, recently laid as a part of the general water supply scheme of Sydney, N. S. W. This main will supplement the supply to North Sydney and will extend the supply to Manly. The pipe

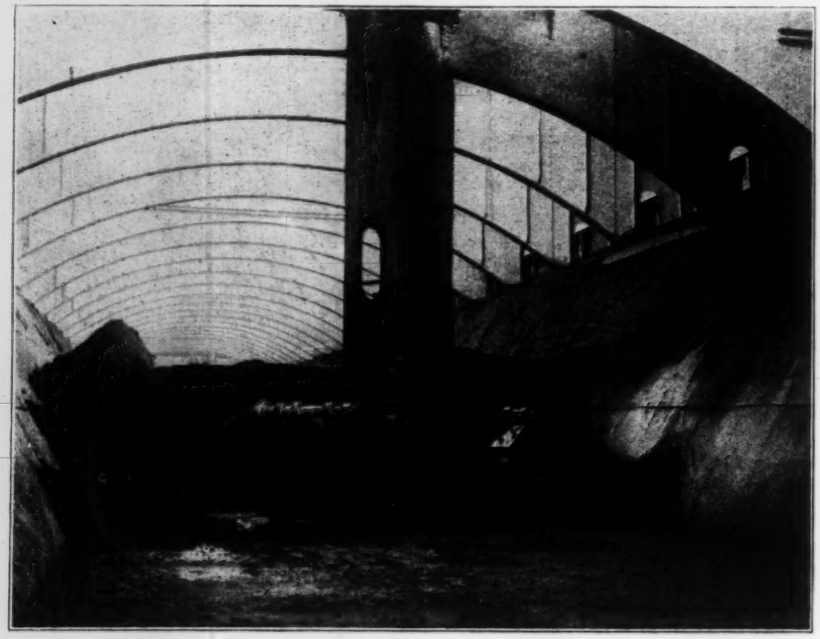


FIG. 3. 10-TON BUCKET OF HULETT ORE-UNLOADING MACHINE.

was made in 28-ft. sections and was provided with manholes at intervals of 330 ft. This style of pipe was devised some years ago by Mr. Mephar Ferguson, of Melbourne. Two semi-circular plates are dovetailed into the two sides of two steel bars and the whole made tight under pressure. In previous issues of this journal several of the earlier examples of the use of locking bar pipe were described.* The joints for the new line for Sydney were formed somewhat differently than were those of the earlier lines which we have described, and the whole of the work of pipe manufacture and laying is so well described in London "Water" for June 15, 1905, that we reprint from that Journal as follows:

PROCESS OF CONSTRUCTION.—The plates are first put through planing machines, where their edges are planed until the plates are true to size. The next machine is known as the buffing machine, and here the plates have their longitudinal edges upset or dovetailed, and the plate is slightly dished. The plate then passes through the rolls, and is ready for the locking-bar. Two of the semi-cylindrical plates, with their dovetailed edges inserted in the H-like recesses of two locking-bars, are clamped up and placed on a carrier, which leads over a powerful hydraulic ram. The closing of the locking-bars upon the plates is performed by a series of squeezes as the pipe is moved forward, and both bars are closed at the one operation. A solid die-head, slightly shorter than the diameter of the pipe, is placed vertically over the hydraulic ram. This die-head is attached to the end of a long arm, extending from the end of the carrier in the longitudinal axis of the pipe. The die-head carries a die at top and bottom, molded to the finished shape of the locking-bar; a similar die is carried by the ram, and another is attached to the crosshead of the machine to hold the top-side of the upper locking-bar. The locking-bars are longer than the plates, and the squeezing process still further elongates them. After coming from the press, these projecting lengths are sawn off. For the Ryde pipe-line (Sydney—Ed.), the portion of the locking-bar passing under the jointing-collar was planed down to allow of sufficient lead between the locking-bar and collar for calking. This operation is the last performed, and the pipe is then ready for testing and coating. The pipes, which will have to stand a maximum pressure due to static head of 75 lbs., were subjected to internal hydraulic pressure of 150 lbs. per sq. in. for pipes ¼-in. thick; 200 lbs. for pipes $^5/_{16}$-in., and 250 lbs. for pipes ⅜-in. thick.

Messrs. G. and C. Hoskins, of Sydney, have taken out a number of patents for improved machinery used in the construction of locking-bar pipes, and carried out the contract for the supply of the pipes used on the Ryde main. When the pipes were subjected to the above tests, only a small percentage had to be rejected on account of leakage along the locking-bar; and since the pipes have been laid no trouble has been experienced from this source. After testing, the pipe is placed in an oven at a temperature of 300° F., and is then dipped into a bath of Trinidad bitumen and maltha heated to a similar temperature. On being lifted from the bath, it is fixed in a lathe and slowly revolved until the coating is set, when the pipe is ready for removal from the works.

METHOD OF LAYING PIPES.—The pipes were laid in trench with 2 ft. of cover. The collars used were 8 ins. wide and $^5/_8$-in. thick, of mild steel, and were of plain cylindrical form, their diameter allowing for ½-in. lead round the barrel of the pipe and $^5/_{16}$-in. over the locking-bar. The pipes were laid with the locking-bars at the sides, as it was anticipated that any leakage occurring would be at the bar, and in that position they were readily accessible for calking. By so placing the bars they were, however, an obstruction to the flow of the lead, and the running of the bottom portion of the pipe caused a good deal of trouble. From the experience gained it is evident that if the bars are to be in position at the side of the pipe the collar should not be cylindrical, but should be shaped to the section of the pipe and bar so as to give ample space over the bar for the flow of the lead.

The joints were run with a revolving lead-pot, which, with its fire-box, traveled along the top of the pipe on rails fastened to saddle pieces. An expander, with four quadrants forced outwards by a central screw and cone, was used for holding the pipes in position and stopping the lead from running through into the pipe. Owing to its occupying the whole space of the pipe and its interference with the examination of the jointing, it was ultimately discarded, and two stiff bars of wrought iron bent into semi-circular form, with a double-acting screw-jack pressing them outwards, was found to be much handier and more effectual.

REPAIRING COATING.—Every care was taken to protect the bituminous coating of the pipes. After the joints were run and calked, the pipe was cleaned round the collar, and, together with the collar, was given two coats of asphaltene paint. Any abrasions to the coating caused in carting or laying were scraped and similarly coated.

DIFFICULTY IN JOINTING.—The difficulty experienced in jointing these pipes was due to the insufficient space left for the passage of the hot lead over the locking-bar, as already indicated, and by the tendency of the water to form a lead along the angle formed by the locking-bar and the plate of the pipe. It is anticipated that in laying further pipes of this class this trouble will be obviated by altering the section of the collar to give more space over the bar and by thoroughly consolidating the lead by calking round the bar.

Small squirts along the bar gradually enlarge and become serious leaks. Such a leak occurred at a point in the pipe-line where there was a static pressure of 75 lbs. to the sq. in. The pipe was allowed to stand full for months, and the damage occurred during that period. The jet of water, in passing between the bar and the lead, was deflected downwards, and gradually eroded a hole through the plate of the pipe, which was of ⅜-in. steel. When this hole was formed, a jet shot out normal to the pipe, cut the lead away, and impinged on the steel collar through the ⅝-in. thickness of which it gradually ate its way until an irregular hole in the collar 3 ins. across in the widest part was formed. The earth in which the pipes were embedded was a sandy loam, and it is probable that the cutting action was materially assisted by the sand continuously falling into the jet.

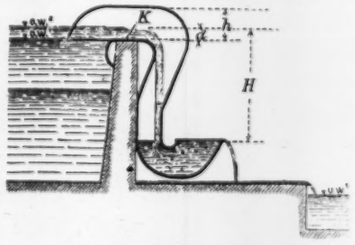
*See Eng. News, June 9, 1898; Dec. 29, 1898, and June 29, 1899.

A SIPHON SPILLWAY FOR DAMS.

The cut herewith shows in section a rather novel device which has been brought out by a German engineer, Mr. J. Heyn, of Stettin, Germany, as a means for discharging over a dam all excess river flow. The device is a simple automatic siphon whose upper end lies approximately in the level of the crown of the weir or dam to be protected, while the lower end, which has a water seal, is at or near the level of tail-water, as may be convenient. The action of the device will be readily understood from the drawing. Normally, with water at or below the level of the crown of the dam, the main body of the siphon is empty, while the water seal at the lower end is filled with water. As the water level behind the dam rises through excess of inflow over draft, the water begins to flow over the bend of the siphon at K, as shown in the figure. This action tends to entrain air from the body of the siphon, which is now trapped, and carry it out by way of the return bend at the bottom; the decrease in pressure in the siphon in turn increases the flow at K, and when a certain point is reached the full action of the siphon is started and water is then discharged under the full difference of head H.

The siphon is simple in construction, is generally made of riveted sheet iron, and can be applied at very slight expense to any existing weir for any desired level of head water. The dimensions of the siphon will, of course, have to be specially adapted to each individual case; the discharge capacity will be determined by the area of cross-section of the siphon tube and by the discharge height H. The readiness with which the device comes into action will depend upon the height h, the air capacity of the siphon, etc.

This siphon device, which has been patented in Germany, presents several distinct advantages over a built-in spillway, or constructing the whole



A Siphon Spillway for Dams.

dam as an overflow weir. As the discharge takes place under the full head H, in place of the mere overfall depth d, the discharge is concentrated, and once started quickly restores the water level to normal. Erosion due to falling water at the foot of the weir is avoided. By the use of such a siphon any dam or weir becomes an embankment without overfall, and the discharge of excess water is concentrated at any desired point without fixed construction. As described in a recent issue of the "Centralblatt der Bauverwaltung," it has been applied to a mill weir in Labes, Pomerania, where it is reported to work satisfactorily. In that case the tube is 14 ins. deep by 3 ft. wide, and the height from head-water to level of water seal is 45 ins.

DRAWBRIDGE ACCIDENT AT MILWAUKEE, WIS.

A serious drawbridge accident occurred at Milwaukee, Wis., on July 19, 1905, when a steamer struck a swing bridge and forced it open just as a street car was passing off the bridge. The accident occurred at the East Water St. bridge, over the Milwaukee River, at 7.30 a. m., when the street was crowded. The bridge had been opened to allow a coal steamer to pass, and was then closed to allow the crowd of passengers, team and cars to cross. Another steamer, the "Kearsarge," which was waiting to pass through the bridge, had drifted close to it, and just as the bridge tenders were preparing to open the bridge again the captain signaled to go astern in order to keep clear. Through some misunderstanding of orders the engine was, however, started ahead. When the bridge tenders saw that the boat would strike the bridge they opened the end locks. The steamer struck the northeast end of the bridge, swinging it open. A long double-truck suburban car for South Milwaukee was passing off the bridge onto the south approach at the time. The bridge swung so far open that the rear truck of this car dropped into the river and only the end of the platform rested on the bridge floor, while the front truck was supported on the approach with one of its wheels overhanging the water.

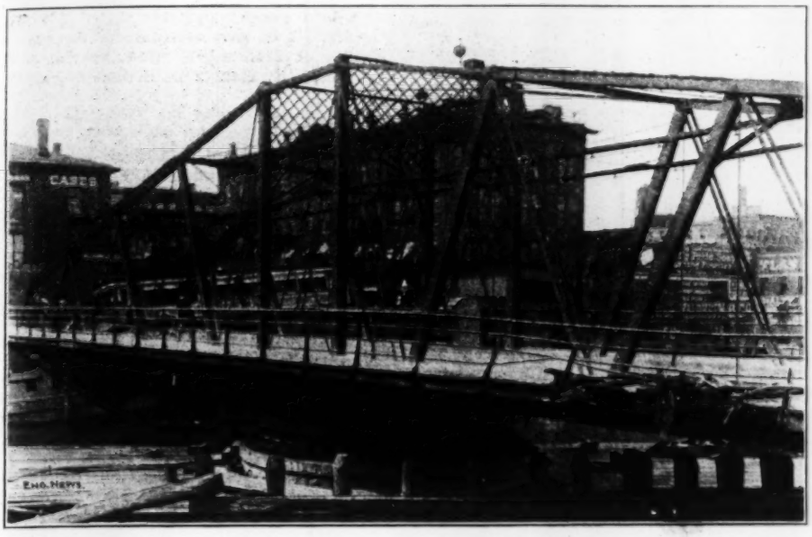


FIG. 1. DRAWBRIDGE WRECKED BY STEAMER; EAST WATER STREET, MILWAUKEE, WIS.
(The gap at the right is where the steamer struck.)

The steamer plowed through the sidewalk of the bridge, and bent the north half of the lower chord of the east truss about 3 ft. out of line, breaking two of the lateral braces and bending the opposite braces. As the bridge swung, the car (being partly on the bridge and partly on the approach) was turned in such a manner as to knock out the end post on the south end of the west truss, breaking the top chord just back of the pin connection. It also broke the two diagonal members of the truss near the lower chord, thus dropping this corner of the floor, which remained suspended from the other truss.

The two photographs reproduced herewith exhibit the damage done by the collision. Fig. 1, a view of the northeast end, shows at the right the point where the steamer struck the bridge, while at the left in the background is the wrecked end post and the floor torn away from its support and bent down by the weight of the car. Fig. 2, a view at the south end, looking toward the approach, shows the car with its rear end barely resting on the bridge and the front truck on the abutment. The end post of the truss has entered the side of the car, and the trolley wire support at the end of the bridge lies across the car.

In order to remove the car, a scow was floated under it and blocking built up until the car could be pulled onto the approach. The car, which was going south from the city, had only a few passengers, and only one person was hurt. Navigation was blocked for some time, and vessels above the bridge were unable to leave port. It is the intention of the city to replace the bridge with a bascule bridge in the near future, but until such time as the necessary legislation can be had, the Board of Public Works has decided to make such repairs as to place the present structure in condition to be used for ordinary traffic. The damaged portions of the bridge have therefore been cut away, and the trusses are being rebuilt with new material in accordance with the original plans, involving the expenditure of about $2,000. For photographs and information concerning the accident we are indebted to Mr. Charles J. Poetsch, M. Am. Soc. C. E., City Engineer of Milwaukee and President of the Board of Public Works.

A similar accident at Houghton, Mich., in which a drawspan was knocked off its pier, was described in our issue of June 1, 1905. It may be noted that as a result of one of the abutments being struck by a steamer on July 28, the old Dearborn St. swing bridge over the Chicago River has been closed to wagon and street car traffic.

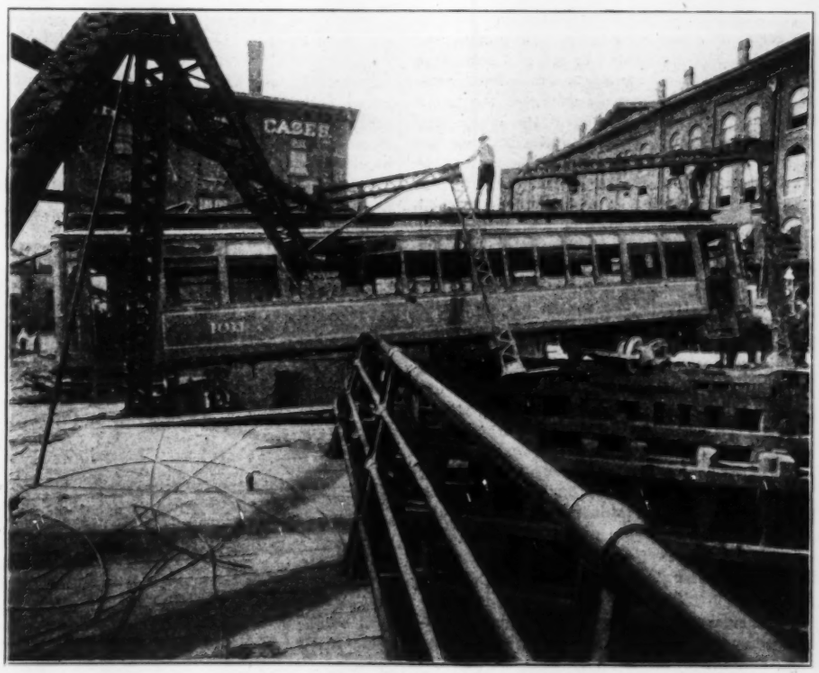


FIG. 2. SOUTH END OF EAST WATER STREET DRAWBRIDGE, SHOWING END POST CARRIED AWAY BY STREET CAR AS THE BRIDGE SWUNG OPEN.

HYDRAULIC ENGINES AT THE U. S. NAVAL COALING STATION, BRADFORD, R. I.

In Engineering News for Dec. 31, 1896, a description of the Rife hydraulic engine was published with an historical sketch of the development of this engine as an outgrowth of the hydraulic ram, and a discussion of the mooted question as to the exact basis on which the efficiency of this class of engine should be figured. Since that article appeared considerable energy has been devoted to the development of this form of engine and a number of successful plants have been put in, among the most conspicuous of which is the one for the water supply system of the U. S. Naval Coaling Station, at Bradford, R. I., on Narragansett Bay.

By courtesy of Mr. Geo. A. McKay, the Inspecting Engineer for the Government, and Mr. G. A. Converse, Chief of Bureau of Equipment of the Navy Department, we are permitted to describe the Bradford installation. The plant consists of two Foster impact engines of the improved type, as shown by Fig. 1, placed side by side upon concrete foundations in a small frost-proof frame house, 18 ft. long, 13 ft. wide and 8 ft. high. The delivery pipes from the engines are connected into an 8-in. pipe and lead to a stand-pipe 30 ft. in diameter and 52 ft. high, located on a hill just above the engine house. The pumping head on the rams, exclusive of pipe friction, is 105 ft. when the stand-pipe is full. Each ram is supplied by a 12-in. drive pipe made of cast iron flanged pipe in which ordinary bolts and rubber gaskets are used. The drive pipes are brought together at the upper ends in a Y connection, to which is attached a 14-in. bell and spigot cast-iron pipe, 275 ft. long, leading from a basin in which the power water is collected. The Y piece is fitted with a flanged opening at the top from which rises the 16-in. stand-pipe to the height of 40 ft., its purpose being to provide a relief chamber at the point which marks the dividing line between the continuous flow of water in the 14-in. pipe from the basin and the intermittent flow in the 12-in. drive pipe leading to

the rams. The location of this stand-pipe is an important feature in this form of apparatus as affecting the efficiency and reliability of the operation.

The engines or rams are of larger size than have hitherto been made successfully, and are rendered possible by the invention of a new form of annular working valve, which has been patented. By means of this valve the maximum area of outlet is obtained for the escape of the water with the minimum unbalanced area which is subject to shock as the valve is closed automatically by the force of the water. The valves are made of carefully selected wood, faced with rubber. They are supported from above through the annular opening by four steel stanchions which are bolted by wrought iron cross bars to a wooden beam acting as a fulcrum. The valve closes on the upper stroke and during the closing compresses an adjustable spring which assists the reaction in

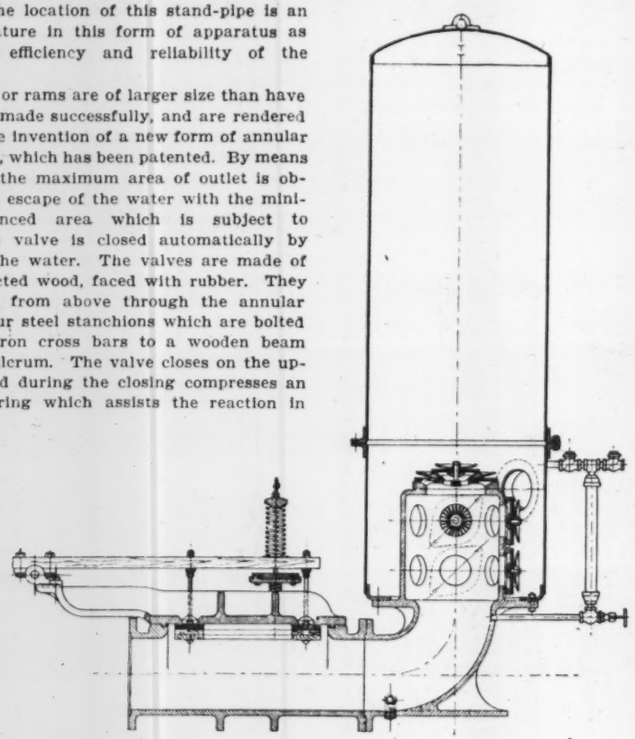


FIG. 1. CROSS-SECTION OF RIFE HYDRAULIC ENGINE.

the drive pipe in reopening the valve. The amount of opening of the valve by which the pumping capacity of the machine is regulated, is governed by an adjustable buffer of ample proportions on which the wooden beam falls. The casting containing this working valve is separate from the main delivery chamber, but the connection is by means of a 12-in. flanged opening, with a recess for a rubber gasket. The delivery valve deck is made a part of this latter casting and is of hexagonal turret form, thus providing for two rows of valves on the sides, making twelve in all, and one large valve on top. The air chamber, which is of sheet steel with cast iron flanges, surmounts the valve chamber and is made in two parts, the lower part being stationary and containing the opening for the delivery pipe, the upper part being removable for the examination of the delivery valves. A strap on the top serves as a convenient method for lifting off the valve chamber, or it is found not difficult to leave one or two bolts in place and merely tip it up when it is desired to inspect the interior. The air pumping device operated by the impact of water in the engine automatically keeps the chamber full of air. One of these engines has a capacity, measured by the power water utilized, of 800 gallons per minute, which at a pumping head equal to three times the driving head would enable it to deliver 200 gallons of water per minute or 288,000 gallons in 24 hours, at an efficiency of 80%. They may, however, be adjusted by regulating the stroke of the working valve to operate continuously on a supply of as low as 200 gallons per minute or probably less.

The plant at Bradford had so many more or less novel features that unusual interest attached to the tests for acceptance, which were conducted by the government engineers.

The power water was measured over a carefully constructed weir in the tail race from the engines and the water actually pumped was determined by measuring the contents of the stand-pipe. The resulting efficiency was so high that it was thought advisable to check the weir measurements; hence a large flat boat was obtained and after being standardized for displacement, was floated under the weir discharge where the time required for filling could be easily observed.

The efficiency guaranteed in the contract was 70%, but the tests showed mean results in excess of this, as follows:

	No. 1.	No. 2.
Total water delivered to engine, gallons per minute	582	578
Water delivered to stand-pipe, gallons per minute	232	228
Power head in engines, ft.	36.75	37.25
Pumping head in ft.	84.0	84.0
Strokes per minute	130	130
Efficiency, per cent. (D'Aubisson formula).	91.23	89.06
Efficiency, per cent. (Rankine formula)...	85.2	81.9

It will be observed that two sets of efficiencies have been included in the table. The Power Specialty Co.,* which has kindly supplied the information on which this article thus far is based, claim that the D'Aubisson formula is the correct one. On this point we cannot do better than to quote what we said in our issue of Dec. 31, 1896:

> The question of efficiency of hydraulic rams has been much discussed, and such authorities as Rankine and D'Aubisson differ considerably in their calculations. Rankine's formula is
>
> $$E = \frac{q\,h}{(Q - q)\,H}$$
>
> where Q is the quantity of water flowing per second in the drive pipe; q, the quantity flowing per second to the stand-pipe through the discharge pipe; H, the height from the escape valve to the level of the reservoir which feeds the drive pipe; and h the difference in level of the water supply reservoir and the water in the stand-pipe. D'Aubisson states the formula for efficiency as
>
> $$E = \frac{q\,(H + h)}{Q\,H}.$$
>
> D'Aubisson's is the correct one, considering the mechanism as a machine receiving energy at one end and delivering it at the other, while if the machine is considered as elevating water only from the one reservoir to the other, Rankine's formula is the correct one to use.

*126 Liberty St., New York City.

THE EXTRACTION OF GREASE FROM SEWAGE AT BRADFORD, ENGLAND, AND ELSEWHERE.

It is well known that all domestic sewage contains more or less grease. In some manufacturing towns, particularly those with wool industries, the grease in the domestic sewage is augmented by that in trade wastes. In our issue of Jan. 16, 1903, we published an illustrated description of the sewage works of Cassel, Germany, combined with which is a grease extraction plant. Our article was founded on a report made to the town authorities of Bradford, England, by Mr. J. Garfield, Assoc. M. Inst. C. E., Sewage Works Engineer of Bradford.

In the Proceedings of the Association of Managers of Sewage Disposal Works* for 1904, which has recently come to hand, there is a paper by Mr. Garfield (read June 11, 1904) on "The Extraction of Grease from Sewage." The Cassel plant is again described in that paper, but not as fully as in the author's report just mentioned. In additon, Mr. Garfield describes the sewage and grease extraction works at Bradford, and gives some information regarding several processes of grease extraction used or proposed elsewhere.

Mr. Garfield first states that the grease which he is considering is not that seen floating on the surface of sewage, but "that which may be perhaps best described as being in solution or emulsion." The average amount of grease in the sewage of seven towns listed in the paper, expressed in parts per 100,000, is as follows: Ilkley, 1.09; Keighley, 9.77; Harrogate, 13.13; Huddersfield, 15.2; Cassel (Germany), 18; Hemsworth, 39.6; Bradford (Frizinghall works), 45.3; Pudsey, 46.8.

THE BRADFORD WORKS.—Some 11,000 acres, or half the area of the town, contribute sewage to the Frizinghall works, the average dry weather flow being 12,000,000 Imp. or 14,400,000 U. S. gallons a day. The present sewage works are temporary, having been built in 1900 to succeed an old and unsuccessful plant, built as far back as 1873 under plans by the Peat Engineering & Sewage Filtration Co. The object of the works is to remove as much suspended matter as possible from the sewage before the latter is discharged into a small stream known as Bradford Beck. Larger and more effective works are to be provided. The works now in use are described by Mr. Garfield as follows:

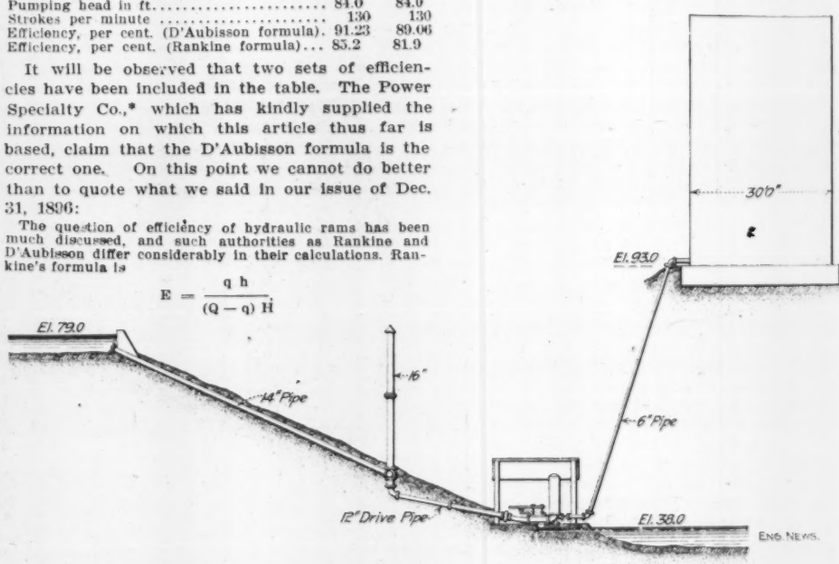


FIG. 2. RIFE HYDRAULIC ENGINE AND CONNECTIONS, U. S. NAVAL COALING STATION, BRADFORD, R. I.

> The sewage, on arrival at the works, passes through a detritus tank of 260,000 (312,000 U. S.) gallons capacity, and through revolving screens to remove the heavy suspended and floating matters. The sewage then receives

*Chas. H. Ball, Secretary; Corporation Sewage Works, Charlton-cum-Hardy, Manchester, England.

a dose of sulphuric acid, which neutralizes the alkali decomposing the soaps. The acidified sewage is then passed into precipitation tanks of special construction. These tanks are twelve in number and of a total capacity of 900,000 (3,600,000 U. S.) gallons. They are worked on the continuous system, the weirs being all level, and the effluent passing away by a culvert which runs under the incoming channels. The sludge is allowed to accumulate in the tanks until they are full to the weir level. By this means the sludge produced contains only 80% of water. The sludge gravitates into a 30-ton (long ton) tank, from which it is forced up by compressed air into the sludge vats in the pressing house, which holds about 2 (long) tons each. Here the sludge is acidified with sulphuric acid and heated up to the boiling point of water by means of steam. From the vat the hot sludge is run into 5-ton (long) sludge rams, of which there are four, and discharged into the filter presses. The presses were made by Manlove, Alliott & Co. They are 32 in number, and they have 45 chambers each 3 ft. sq. The air-pressure used is 60-lbs. per sq. in. It is necessary to keep the filter presses hot during the operation of pressing. This is done by heating up the press when empty by means of steam, and keeping the sludge feeding them in a hot condition. The grease recovered in this way flows from the presses with the "press liquor," and is easily separated therefrom by allowing the hot liquor to flow into vats in which the grease comes to the top. The grease is then run off into other vats, purified, allowed to cool, and finally barreled. In this way 20% of the grease contained in the sludge is recovered. This press-cake contains about 25% grease and only 30% moisture. The amount of grease remaining in the cake depends upon the nature of the other solids in the sludge. When these other solids are chiefly sand it is possible to press out the grease so that only 15 or 16% of grease remains. It has been found that by using a very great pressure it is not possible to recover more of the grease.

A press cake containing so much grease is not suitable for use as a manure. At Frizinghall it is proposed to extract the grease by distillation, and a plant for this purpose is now being put down. In the first place only a portion of the pressed cake will be dealt with in this way by means of eight retorts, into which the cake will be fed, and in which it will be heated up to about 600° F.; at this temperature the grease volatilizes. The vapors will be drawn out and condensed. With an experimental plant, designed by the author, it was found that practically all the grease could be extracted and the cake left in a dry powder containing all the nitrogen of the original cake, and of considerable value as manure. The sulphuric acid used per day amounts to about 25 (long) tons, the daily dry-weather flow being 12,000,000 (14,400,000 U. S.) gallons; 250 to 400 (long) tons of sludge are pressed per day, producing 60 to 100 (long) tons of cake.

THE DELATTRE PROCESS.—A system invented by M. Delattre, of Douai, France, was tried experimentally at Bradford and has been used at the sewage works of Roubaix at Grimonpoint, France. The wet sludge is passed through a series of inclined cylinders, having an aggregate length of 200 ft., and fitted with revolving paddles. A light solvent, such as benzine, is pumped into the lower end of the cylinders and on passing upward and through it becomes charged with the down-flowing sludge. The solvent and grease are taken out at the top of the apparatus and afterwards they are separated. The treated sludge is heated with steam to remove any remaining solvent and then filter-pressed hot. The resulting dry coke is said to be available for manure.

THE VIAL PROCESS.—Emile Vial, a chemical engineer of Brussels, has built a plant at Haren-Nord, a suburb of Brussels, to deal with the sewage from 5,000 people. Detritus tanks, preliminary settling tanks, "screens of metallic netting" and precipitation tanks are used in succession. The latter are fed by means of automatc siphons, in conjunction with which sulphuric acid is automatically introduced as a precipitant. Weirs at exactly the same level serve as inlets to and outlets from these tanks, the aim being to distribute the incoming liquid in a thin sheet over the liquid already in the tank. The process is further described as follows:

The sludge drawn off from the bottom of the tanks is first mechanically concentrated in a cylindrical receiver divided into two sections by a filtering partition. In the top partition the sludge is received, the thickened sludge being heated and liquefied by a steam coil. A revolving screw forces the sludge to spread itself over the filtering area. The water is collected in the lower partition, and the sludge passes on to a large vat. This vat contains the sludge is heated until completely dehydrated. The vat contains a steam coil, an agitator and a scraper provided with bent blades for clearing the bottom. Superheated gases are introduced into the vessel, and under tains a certain quantity of greasy substance, with which the action of the agitator and of the heat, the sludge, which is very much diluted by the grease added, passes into an anhydrous state; then, assisted by the scraper, it falls to the receiver arranged underneath.

The residue, thus dried, is next treated with a solvent. This is effected by allowing it to drop into a closed vessel with a semi-cylindrical bottom, heated by steam, and provided at its ends with air-tight doors. This vessel encloses large screw conveyors turned in opposite directions by means of gear wheels. This screw conveyor is formed by two series of blades having pitches in opposite directions, from the center towards the ends. The blades are formed of a double series of large outer spirals of opposite pitch, and a double series of smaller inner spirals, also of opposite pitch, but arranged in inverse direction to the preceding ones. The mass introduced into the vessel is worked backwards and forwards by means of the conveyors in a bath of solvent.

The residue thus repeatedly mixed with the volatile solvent is completely scoured. The discharge of the insoluble residue is effected by means of the screw conveyors, which are rotated in such a manner as to force the material towards the two openings arranged at the ends of the vessel. The insoluble material is then heated in a suitable vessel, and the solvent recovered for re-use. The final residue is a dry powder which is disposed of as a manure.

The solvent used for scouring the residue is distilled off in the usual way, leaving the recovered grease behind.

THE SPENCE PROCESS.—Messrs. Spence, of Manchester, England, have patented a grease extraction process similar to the one used at Cassel. The sewage is treated with ferric sulphate and sulphuric acid "in such proporton that the alkalinity of the liquid is completely neutralized and the grease is precipitated along with the putrescible matter." The sludge is dosed with sulphuric acid, then heated and filter-pressed. After having been dried the sludge coke is treated with a solvent for the extraction of the grease. As is usual in other cases, the promoters of this process claim that the final sludge is a valuable manure.

For the convenience of those who have not our issue of Jan. 15, 1903, at hand, it may be said that Cassel has a population reported two years ago as 107,000, and that in 1902 the sewage dealt with had a daily flow of a little more than 3,000,000 U. S. gallons. The sewage receives considerable amounts of acid wastes from works for the recovery of tin from scrap iron, aside from which no precipitants are used. The treatment consists of sedimentation, followed by screening at the outlet weirs. The sludge is screened, acidified, heated, pressed, disintegrated, dried and finally treated with benzine. The process was invented by the late Paul Degener, and is covered by British patent No. 21,856, dated 1901. The city delivers the sludge to a private company under a 20-year contract. The company is under agreement to treat the sludge without nuisance, but so far as it appears from the information in hand there is no payment made by either party to the contract.

A HANDY DRAWING BOARD FOR FIELD USE.

By E. B. Darlington.*

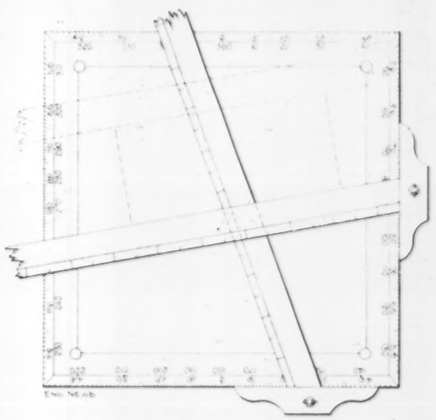
The accompanying sketch is a diagram of a handy drawing board which I have designed for use in the field, where the movements of the surveying party are so rapid that a table is too cumbersome and slow. The chief merits of this board are compactness and convenience, only one accessory being necessary for drawing lines at any angle, and the simplicity of its construction and use.

The essential features are a truly square board of soft wood, the edges of which are graduatel to degrees, half degrees or quarter degrees, as may be desired; and a T-square with movable head, the blade graduated on one edge to the scale desired.

The board may be ½-in. thick and for the other dimensions 15 ins. square is a convenient size. On the back of the board may be attached a pocket of canvas or oilcloth, in which to carry blank or finished sheets, maps, etc., and a handle or shoulder-strap may be fastened to the edges.

The blade of the T-square should be just long enough to reach diagonally across the board and preferably should be of transparent material, such as xylonite. It should be so constructed that the blade will swing in the head almost to a full half-circle, and with a thumb-screw to tighten it at any angle.

For use, the drawing paper is centered within the protractor and the center marked by a pinhole. The draftsman sits down, with the board on his lap, alongside of the transitman, who calls the shots to him. The angles may be called either by azimuth, or by quadrant bearing, and the draftsman will in either case hold the T-square blade at the center point and run the head along some edge until the proper angle is reached, when he clamps the head and shifts the entire T-square along the edge to the point for starting the line, drawing the same against the blank edge and scaling off the distance with the graduated edge. The sketch shows how the T-square can be used on any edge and shifted to any point on the board,



A Drawing Board for Field Use.

and it will be seen that no protractor, triangles or other tools are needed, points that will be appreciated by anyone having experience in field drafting.

The board was designed especially for use on the lands surveyed by the government into sections of one mile square, and blanks measuring 5,280 ft. on a side to a scale of 500 ft. per in., and sub-divided into 40-acre tracts by dotted lines, are very convenient for mapping such sections. If frequent ties to section corners are made it is almost impossible to overlook an error in either the instrument work or drafting. In connection with stadia work, where rapidity is more important than painful accuracy, these boards are especially serviceable.

*Field Manager for the State Engineer of Idaho, Boise, Idaho.

ENGINEERING MATERIAL PRICES.

TRACK FASTENINGS—
New York—at mill—Angle bars, 1.25 to 1.40 cts.; spikes, 1.70 to 1.75 cts.; bolts, square nuts, 2.15 cts.; bolts, hexagonal nuts, 2.40 cts.

RAILS, STEEL—
New York—at mill—New standard sections, $28; standard, second quality, $27; light sections, 12 to 25 lbs., $20.50 to $23; old iron, f. o. b. New York, $21 to $22; old steel, rerolling lengths, $13.25 to $14.25; old steel, short pieces, $14 to $14.50; relayers, $19.50 to $20.50.
Chicago—at mills—New, $28, standard sections; light rails, $24 to $27; old iron rails, f. o. b Chicago, $18.75 to $19.25; old steel, $14 to $14.50; relayers, $23 to $23.50.
Pittsburg—at Mill—Standard sections, $28; old steel rails, f. o. b. Pittsburg, $13.50 to $14.

STRUCTURAL MATERIALS—
New York—at tidewater—Beams and channels, up to 15-in., 1.74½ cts.; over 15-in., 1.84½ cts.; angles, 3 × 2 and up to 6 × 6, 1.74½ cts.; zees and tees, 1.79½ cts.; steel bars, half extras, 1.64 cts.

PLATES AND SHEETS—
New York—at tidewater—Sheared plates, tank, 1.74½ to 1.84½ cts.; flange, 1.84½ to 1.94½ cts.; marine, 1.94½ to 2.04½ cts.; still bottoms, 2.04½ cts.; fire box, 2.24½ to 3.05 cts.
Pittsburg—Tank, ¼-in. thick and heavier, 1.60 cts.; black sheets, 27 gage, 2.20 cts.; black sheets, 28 gage, 2.25 cts.

IRON—
Pig Iron:
New York—tidewater—No. 1 X Foundry, Northern, $15.75 to $16; No. 2 X Foundry, Northern, $15.25 to $15.75; No. 2, Plain Foundry, $14.25 to $14.75; Gray Forge, Northern, $14 to $14.25; Basic, Northern, $14.75 to $15.25; Basic, Alabama, $15.75; Basic, Virginia, $15.65; No. 1 Virginia Foundry, $17.15 to $17.40; No. 2 Virginia Foundry, $16.65 to $17.15; No. 1 Foundry, Southern, $16.25; No. 2 Foundry, Southern, $15.50 to $15.75; No. 3 Foundry, Southern, $15.25; No. 4 Foundry, Southern, $14.50 to $14.75;

No. 1 Soft, Southern, $16.75; No. 2 Soft, Southern, $15.50 to $15.75; Gray Forge, $14 to $14.25; Mottled, $13.75 to $14.

Pittsburg—f.o.b. cars—No. 2 Foundry, $15.35; Gray Forge, $14.85; Bessemer Iron, $15.85; Ferro Manganese, $50.25; Muck Bars, $28.50 to $29; Iron Bars, $1.50 to $1.60.

Cast-iron Pipe:
New York—Carload lots, net tons, 6-in., at tidewater, $27.
Chicago—4-in. water pipe, $29; 6-in. and larger, $28, with $1 extra for gas pipe.

MISCELLANEOUS MATERIALS—

Asphaltum:
Ventura and other California asphalts, $20 to $21 per ton at New York; Trinidad refined, $25 to $30 per ton; Venezuela asphalt, $25 to $30 per ton; Bermuda asphalt, $25 to $30.

Cement:
Rosendale, in wood, $1; Portland, domestic, $1.70 to $1.80; Foreign brands, $2.25 to $2.50.

Copper:
Lake, 15.25 to 15.50 cts.; electrolytic, 15.25 to 15.50 cts.; casting, 14.87½ to 15.12½ cts.

Lead:
New York spot, 4.60 to 4.70 cts.

Spelter:
New York, spot, 5.55 to 5.65 cts.

Tin:
New York, spot, 32.62½ to 32.75 cts.

Tar:
New York, $6.25 per bbl.

Pitch:
New York, $2.80 to $2.85.

LUMBER—
New York, wholesale prices:
Piling—Spruce, ordinary cargoes, 6 to 7 cts.; oak, 14-in. butt, 40 to 50 ft., 19 cts.; 50 to 55 ft., 22 cts.; 55 to 60 ft., 23 cts.; 60 ft. and up, 25 cts.; pine, 60 to 65 ft., $8.50; 70 to 75 ft., $10.50; 80 ft. and up, $16.
Railroad ties—Yellow pine, 6 × 9 ins. × 8 ft., 62 to 63 cts.; 6 × 8 ins. × 8 ft., 57 to 58 cts.; 7 × 9 ins. × 8 ft., 72 to 73 cts.; 7 × 8 ins. × 8½ ft., 68 to 70 cts.; 7 × 9 ins. × 8½ ft., 73 to 75 cts.

A SERIOUS RAILWAY ACCIDENT IN ENGLAND occurred on July 27. A rear collision between electric trains on the suburban section of the Lancashire & Yorkshire Ry., near Liverpool, caused the death of 22 persons. Several cars were burned in a fire which followed the wreck.

THE YELLOW FEVER OUTBREAK AT NEW Orleans had resulted in some 200 or more cases and about 60 deaths up to Aug. 1. The infection appears to have been spread to numerous sub-centers of infection, mostly by Italians, before the outbreak was recognized or at least before it was fully taken in hand by the authorities. The outcome will be particularly interesting in view of the fact that this is the first outbreak of yellow fever in this country since it was determined that the mosquito is the vehicle of infection from man to man.

PERSONALS.

Mr. Richard T. Mannix has been appointed City Civil Engineer of Anderson, Ind.

Mr. B. B. Kelliher has been appointed Chief Engineer of the Grand Trunk Pacific Ry., with headquarters in Montreal, Que.

Mr. F. A. Peterson has been appointed Division Engineer of the Southwest Division of the Chicago Great Western Ry.

Mr. S. E. Cotter has been appointed General Superintendent of the Wabash Ry., succeeding Mr. H. L. Magee, who has resigned.

Mr. F. E. Watson, a civil engineer of Albion, Neb., has been appointed Assistant Engineer, Isthmian Canal Commission, for duty on the Panama Canal.

Mr. Herbert Murphy has been appointed Division Engineer of the Missouri Pacific Ry., at Kansas City, Mo., in charge of the construction of new yards.

Mr. J. Kraus has been nominated by the Netherlands Government as its Member of the Board of Consulting Engineers of the Isthmian Canal Commission.

Wm. Gerig, M. Am. Soc. C. E., formerly Superintendent of Dredging of the Mississippi River Commission dredges, has been appointed a Division Engineer for the Panama Canal.

Mr. C. B. Stanton has been appointed engineer in charge of construction of the new line of the Chicago & Alton Ry., from Springfield to Murrayville, Ill., with offices at Springfield.

Mr. M. A. Hansen, Engineer of River Protection on the Missouri Pacific Ry., has been appointed Chief Engineer of the Arkansas Southern R. R., with headquarters at Ruston, La.

Mr. Horace B. Gale, of Natick, Mass., and Miss Mary E. Eastman, of Keene, N. H., were married July 25 in the latter city. Mr. Gale is a civil engineer, employed in Boston, Mass.

Mr. D. O'Brien has been appointed Assistant to Mr. F. W. Morse, Vice-President and General Manager of the Grand Trunk Pacific Ry., and will have his headquarters at Winnipeg, Canada.

Mr. H. Fernstrom, M. Am. Soc. C. E., has resigned his position as Chief Engineer of the New York Central & Hudson River R. R., and has been appointed Chief Engineer of the Tidewater R. R.

Mr. Paul A. Kirchner, formerly Bridge Engineer of the Chesapeake & Ohio R. R., has been appointed Bridge Engineer of the New York, Westchester & Boston Ry., with headquarters in New York City.

Mr. John H. Janeway, Jr., M. Am. Inst. Min. E., has resigned his position in the Engineering Department of John A. Roebling Sons Co., to become General Manager of the Mineral Point Zinc Co., of Chicago.

Mr. Andrew Maclean, Constructing Engineer of the Colorado Fuel & Iron Co., has been appointed Chief Electrician and Constructing Engineer of the Oregon Railroad & Navigation Co., with headquarters at Portland, Ore.

Mr. H. N. Sims, M. Am. Inst. Min. E., for five years manager of the mines of The Sun & Moon Mining & Milling Co., at Idaho Springs, Colo., has accepted a similar position with the Bellfonte Coal & Coke Co., at Punxsutawney, Pa.

Mr. William H. Ten Eyck has resigned as President of the Acqueduct Commission of New York City, and is succeeded by Mr. John F. Cowan, who was appointed a member of that board about three months ago to succeed Mr. William E. Curtis.

Mr. W. E. Mott, Assoc. M. Am. Soc. C. E., has severed his connection with Cornell University and has removed to Boston in order to accept an associate Professorship in the Department of Civil Engineering in the Massachusetts Institute of Technology.

Mr. F. B. Scheetz, hitherto Assistant Engineer of the Missouri Pacific Ry., at St. Louis, Mo., has been appointed Engineer of Bridges and Buildings of that road and of the St. Louis, Iron Mountain & Southern Ry., with headquarters at St. Louis, Mo., succeeding Mr. E. Fisher.

Mr. Carl Koch, who has become associated with the recently organized firm of Ernst Wiener Co., of 68 Broad St., New York, was formerly Engineer for the New York office of Arthur Koppel, and was never, as was stated in our issue of July 13, Chief Engineer for that firm.

Mr. H. J. MacNair, Assoc. M. Am. Soc. C. E., who has been associated with the Scarborough Company, map publishers, at their Boston office, has removed to Indianapolis, the home office of the company, where he will be in charge of their department of Geography and Drafting.

Mr. G. P. Smith, heretofore Engineer of Maintenance of Way of the Indiana, Illinois & Iowa R. R., has been appointed Chief Engineer of the Lake Erie & Western R. R. and the Indiana, Illinois & Iowa R. R., with headquarters at Indianapolis, Ind., to succeed Mr. E. A Handy.

Mr. Cecil B. Smith, M. Can. Soc. C. E., of Niagara Falls, Ont., has been appointed Chief Engineer of the Ontario Hydro-Electric Commission of Ontario, Canada. Mr. Smith will also continue to act as Chairman and Consulting Engineer of the Temiskamnig Railway Commission.

Mr. George H. Webb, M. Am. Soc. C. E., has been promoted from Assistant Chief Engineer to Chief Engineer of the Michigan Central R. R., succeeding Mr. W. S. Kinnear, who is now in charge of the Michigan Central R. R. tunnel line under the Detroit River, between Detroit and Windsor.

Mr. G. A. Berry, heretofore Bridge Engineer of the New York Central & Hudson River R. R., has been appointed Assistant to the Principal Assistant Engineer of the Electric Zone, with headquarters at Grand Central Station, New York City. Mr. C. P. Marsh succeeds Mr. Berry as Bridge Engineer.

Miss Elsie Bittman, of Brooklyn, N. Y., as the result of a Civil Service examination, which she passed at the head of the list, has been appointed to a position as topographical draftsman in the Bureau of Highways of Brooklyn. She is the first woman to receive such an appointment in that Borough.

Mr. J. Waldo Smith, M. Am. Soc. C. E., has resigned his position as Chief Engineer of the Acqueduct Commission of New York City and will become, it is stated, Chief Engineer of the new commission which has been appointed by Mayor McClellan, of New York, to provide an additional water supply for that city.

Obituary.

Jacob C. Chamberlain, M. Am. Inst. El. E., of 100 Broadway, New York, died July 28 in that city. He was a graduate of Rutgers College.

Robert F. Johnson, a civil engineer for many years in the U. S. Assay Office in New York City, died recently at his home in Brooklyn, N. Y.

A. J. Parker, a mining engineer of Cleveland, O., was instantly killed July 21 by lightning at Whitney, 15 miles south of Salisbury, N. C. Mr. Parker had recently completed the installation of an electric plant on the Yadkin River for the Whitney Reduction Co.

ENGINEERING SOCIETIES.

COMING MEETINGS.

NATIONAL IRRIGATION CONGRESS.
Annual convention, Portland, Ore., Aug. 21-4. Secretary, Tom Richardson, Portland, Ore.

LEAGUE OF AMERICAN MUNICIPALITIES.
August 23 to 25. Annual meeting at Toledo, O. Secy., J. McVicar, Des Moines, Ia.

INTERNATIONAL ASSOCIATION OF MUNICIPAL ELECTRICIANS.
August 23 to 25, 1905. Annual convention at Erie, Pa. Secy., F. P. Foster, Corning, N. Y.

AMERICAN PUBLIC WORKS ASSOCIATION.
August 30, 31, 1905. Annual meeting at Chattanooga, Tenn. Secy., W. H. Flint, Chattanooga, Tenn.

AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS.
Sept. 5 to 7. Annual meeting at Montreal, Canada. Secy., Geo. W. Tillson, Brooklyn, N. Y.

ROADMASTERS & MAINTENANCE OF WAY ASSOCIATION.
Sept. 12, 14. Annual meeting at Niagara Falls, N. Y. Secy., C. E. Jones, C., B. & Q. Ry., Beardstown, Ill.

AMERICAN ELECTROCHEMICAL SOCIETY.
Sept. 18 to 20. Annual meeting at Bethlehem, Pa. Secy., S. S. Sadtler, 39 S. 10th St., Philadelphia, Pa.

AMERICAN STREET RAILWAY ASSOCIATION.
Sept. 25-30. Annual convention at Philadelphia, Pa. Secy., T. C. Penington, 2020 State St., Chicago, Ill.

NEW ENGLAND WATER-WORKS ASSOCIATION.
Sept. 13 to 16. Annual convention at New York, N. Y. Secy., Willard Kent, Narragansett Pier, R. I.

ASSOCIATION OF RAILWAY SUPERINTENDENTS OF BRIDGES AND BUILDINGS.
Oct. 17. Annual meeting at Pittsburg, Pa. Secy., R. F. Patterson, Concord, N. H.

MAINTENANCE OF WAY MASTER-PAINTERS' ASSOCIATION.
Nov. 13, 14. Annual meeting at Cincinnati, O. Secy., H. J. Schnell, 100 William St., New York, N. Y.

LEAGUE OF AMERICAN MUNICIPALITIES.—The following papers and addresses are on the program of the coming annual convention of the League of American Municipalities: Presidential address, by Wm. C. Crolius, Joliet, Ill.; "Municipal Finance and Accounting," by L. G. Powers, of Washington, D. C. (and discussion led by L. Betz, of St. Paul, Minn.); "St. Louis' Municipal Lighting Plant," by J. W. Wood, of St. Louis, Mo.; "How to Tax Real Estate," by P. Witt, of Cleveland, O.; "Workhouses," by F. R. McDonald, of Minneapolis, Minn.; "Municipal Ownership," by Mayor R. H. Jeffrey, of Columbus, O.; "The Street Railway Situation in Toronto," by F. S. Spence, of Toronto, Ont.; "Abatement of the Smoke Nuisance," by R. P. King, of Indianapolis, Ind.; "Should Disinfectants Be Standardized," by W. S. Crandall, of New York, N. Y.; "What the Great Fire Has Accomplished for Baltimore," by Judge O. Leser, of Baltimore, Md.; "Factors in Asphalt Paving Construction, Maintenance, and Cost," by A. Rosewater, of Omaha, Neb.; "Fire Department Water Supply," by C. A. Hague, of New York, N. Y.; "Street Cleaning," by Mayor S. Cook, of East St. Louis, Ill.

APPALACHIAN ENGINEERING ASSOCIATION.—This new society held its regular meeting at Williamson, W. Va., on Saturday afternoon, July 22, with all the officers and a large number of members present. President F. W. Callaway addressed the Association in well-chosen words, setting forth the definite purpose and aims of the organization, and it was voted to include this address in the publications of the Association. Routine business was then transacted, the constitution adopted, and the date for the next meeting set for 3 p. m., Sept. 16, 1905, at the Florentine Hotel, Huntington, W. Va. Papers to be read will be announced later. Secy., H. M. Payne, Williamson, W. Va.

INTERNATIONAL ASSOCIATION OF MUNICIPAL ELECTRICIANS.—The Erie convention, August 23 to 25, will have the following papers presented for discussion: "The Effects of Electrostatic Influence in Telephone and Telegraph Circuits," by H. R. Allensworth, of Columbus, O.; "The Advisability of Fusing Fire and Police Telegraph Boxes," by C. E. Diehl, of Harrisburg, Pa.; "Electric Light Engineering," by A. S. Hatch, of Detroit, Mich.; "Erection and Maintenance of Electric Lighting Plants," by C. L. Williams, of Meridian, Miss.; "Suggested Improvements in Fire Alarm Telegraph Systems," by Wm. Brophy, of Boston, Mass.; "The Necessity of a Rigid Inspection by the Municipality," by T. C. O'Hearn, of Cambridge, Mass.; "Underground Construction," by Louis Gascoigne, of Detroit, Mich. The headquarters of the association during the convention will be at the Reel House. Secy., F. P. Foster, Corning, N. Y.

STREET RAILWAY EXHIBITION.—The exhibition of street railway appliances, which has always been a feature of the conventions of the American Street Railway Association, will in the future be conducted by a subsidiary organization formed a year ago, the American Street Railway Manufacturers' Association. The first exhibition to be directed by this association will take place in the South Pavilion of the Philadelphia Museums, Philadelphia, Pa., Sept. 25 to 30, 1905. The apportionment of space is now being arranged. Mr. George Keegan, 13 Park Row, New York, is secretary of the manufacturers' organization.